THE

IRON
ANUFACTURER'S GUIDE

TO THE

FURNACES, FORGES AND ROLLING MILLS

OF

THE UNITED STATES

WITH

DISCUSSIONS OF IRON

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AL ELEMENT, AN AMERICAN ORE, AND A MANUFACTURED ARTICLE, IN COMMERCE AND IN HISTORY.

BY J. P. LESLEY,

S CRETARY OF THE AMERICAN IRON ASSOCIATION,

AND

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THE IRON MANUFACTURER'S GUIDE.

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☞ Corrections for subsequent editions are earnestly requested, and may be addressed to the office of the *American Iron Association Box Philadelphia Post Office.*

PART I.

THE IRON MANUFACTURER'S GUIDE

TO THE FURNACES, FORGES, AND ROLLING MILLS OF THE UNITED STATES.

TABLE A.

ANTHRACITE BLAST FURNACES IN THE UNITED STATES.

1. 2. Berkshire Anthracite Steam Iron Works, near the West Stockbridge Railroad Station, Berkshire county, Massachusetts, Gay & Burt, owners; an incorporated company. Two furnaces; No. 1, built in 1853, 12 feet bosh, 32 feet high. No. 2, built 1857, 16 × 41. The mines are five to seven miles distant, and furnish brown hematite. No. 1 furnace produced, in 1855, 4,612¼ tons hot-blast iron.

The iron making district of Western New England embraces Berkshire county, Massachusetts, the northwest of Litchfield county, Connecticut, and the east of Columbia and Dutchess counties, New York. The ore is a brown hematite, deposited in clay and gravel banks, along fissures and hollows in the lower Silurian Limestone, near its inferior limit, in lines parallel with the Highlands, Berkshire, or Green Mountains. These are different names for the same range. Some of the hematite deposits have been wrought since before the revolutionary war, and have yielded a hundred thousand tons of washed ore without showing signs of exhaustion. The rock ore is not washed. Roasting is now practised only by a few cold-blast charcoal furnaces. Subterranean mining has also been aban-

doned, and open quarrying or stripping is the only method now employed. The ores obtained vary, of course, in quality. *Two tons and an eighth* of mixed Richmond, Shaker, and West Pittsfield bank ore has made a ton of iron, on an average, during six months. The iron made with hot-blast is soft foundry; with cold-blast and charcoal, the superior forge iron known as Salisbury. The make of charcoal cold-blast iron would rapidly increase in this region but for the scarcity of fuel, a scarcity aggravated by the wood-burning locomotive railway demand. Fuel costs the charcoal furnaces about $10 50 per ton of iron.

3. Stockbridge Anthracite Iron Works (Water), in Berkshire county, Massachusetts, have one charcoal furnace (see Table B, No. 12) and one anthracite furnace, 10 feet bosh, built in 1845, and out of blast since 1855. It used to average 7 tons per day for 40 weeks.

4. Sharon Station Anthracite Steam Furnace, owned by Hiram Weed & Co., Corkenstown, Dutchess county, New York, near the Massachusetts line, was built in 1854, 9 feet bosh, swelling in the cylinder to 10 feet, and 32 feet high. The Megat ore banks are within a stone's cast of the furnace, an open quarry of loam, sand, blue clay, and brown hematite ore balls, shells, pipes, and mammillary masses, thrown down irregularly on one another, in variable quantities and qualities in level layers, horsebacks, and lenticular deposits, with every appearance of tumultuous in-washing. No bottom at 25 feet. Amenia bank is 3 miles north, and Salisbury bank northeast.

5. Bull's Falls Anthracite Water Furnace, four miles south of Kent Station, on the Housatonic Railroad, Litchfield county, Connecticut, owned by D. and E. Wheeler; was built in 1826 for charcoal, 8 feet bosh, and 30 high; rebuilt in 1844, 14×40, and reduced in 1857 to $9\frac{1}{2} \times 34$, because too large for its water power. Its former capacity was $3\frac{1}{2}$, its present, 8 tons per day. The Quakerhill and Kent ore banks are $4\frac{1}{2}$ miles west, and 3 miles east of it.

6. 7. Port Henry Anthracite Furnaces, one water and the other steam, stand on the west shore of Lake Champlain, in Essex county, New York, near Old Crown Point, owned by the Port Henry Furnace Company, John H. Reed, of Boston, Trea-

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surer, and John H. Reed and W. T. Foote, Managers. Furnace No. 1 was built in 1847, 13½ feet across the bosh, by 42 feet high, but little used until 1854, when it made 3,553 tons. No. 2 was built in 1854, of boiler iron, on cast iron columns, 16×46. Both furnaces produced, in 1856 9,730 tons, from magnetic ore from the Cheever mine, 1¼ miles northwest of the furnaces, and near the lake. This grand bed of ore, and another of nearly twice its thickness, called the Sanford bed, 3 miles west of the furnace, are among the most famous magnetic iron ore mines of the northern States. No. 2 produced, in 40 weeks of 1857 5,321 tons.

8. **Siscoe Anthracite Steam Furnace,** at Westport, Essex county, New York, on the west shore of Lake Champlain, was built for charcoal in 1845, and began to use anthracite in 1853. It was rebuilt in 1856, 13 feet in the bosh, and 42 feet high, and made 4,200 tons of chiefly white iron from magnetic ore in 1856. In 1857 3,741 tons in 31 weeks.

9. **Fort Edward Anthracite Furnace,** using the Hudson River at Fort Edward, Washington county, New York, for water power, and owned by the Fort Edward Blast Furnace Company, J. A. Griswold, of Troy, Treasurer, C. C. Alger, of Hudson, Agent, had new machinery in 1856, and was destroyed. It was 18½ feet in the bosh, 50 feet high, and used Sanford magnetic ore for the most part, mixing it with a little fossil ore from Utica, and some ore from a new bed opened at Fort Anne.

10. **Clinton Anthracite Steam Furnace,** nine miles west of Utica, Oneida county, New York, owned by S. A. Munson, of that place, was built near the northern outcrop of that wonderful Lower Silurian deposit of small shells and oxide of iron which underlies the whole Catskill and Alleghany Mountains, and comes up at Danville and Bloomsburg, on the North Branch of the Susquehanna, in Pennsylvania; the same that is mined at the Cumberland Gap and elsewhere for Claibourne and other furnaces in Tennessee.

11. 12. **Hudson Anthracite Steam Furnaces,** at the south end of Hudson, Columbia county, New York, between the railroad and the river bank, owned by the Hudson Iron Company, Sydney Seymour, Secretary, and C. C. Alger, co-owner, contractor, and agent, were built together in 1850, each 16 feet in

the bosh, and 45 high, and are blown together by one large beam engine, weighing 100,000 lbs., with a bed plate 34 feet long. They made, in 1855 14,424 tons of iron, from 60 per cent. of West Stockbridge brown hematite, 1½ miles east of the village, and 40 per cent. of Fort Montgomery, or old Forest of Dean magnetic ore.

13. 14. Poughkeepsie Anthracite Steam Furnaces, half a mile below Poughkeepsie, Dutchess county, New York, on the Hudson River Railroad, owned by the Poughkeepsie Iron Works Company (Bech & Kuhnhardt), A. Town, manager, were built, the first in 1848, 13½ feet across the bosh, by 43 feet high, and the second in 1853, at first 18, then 15 feet by 46. In 1856 they made 4,928 and 5,480 tons, from three-eighths Cheever magnetic, and five-eighths Hopewell brown hematite, 18 miles to the east-southeast. No 2 used one-half and one-quarter, and added one-quarter Utica fossil.

15. Napanock Anthracite (water) Furnace, 25 miles southwest of Kingston, and on the Rondout River and Delaware and Hudson Canal at Napanock in Ulster county New York, owned by F. Bange and managed by M. S. Brinton, was built 9 feet across the boshes, by 30 feet high, and made 1,700 tons in 39 weeks in 1856. Its ore is a peculiar, solid, dark grey, homogeneous ore, probably of Devonian age (No. 8 Pennsylvania survey), containing small geodes of sulphuret of iron, and lenticular fragments of metamorphic clay slate and occasional markings as if of fossils, but not organic. The mine is one-third of a mile south of the furnace.

16.5. Croton Patent Anthracite Furnace, owned by Nichols & Company, managed by D. L. Merrit, and designed to make wrought iron directly from the ore, is situated at Croton Landing on the North River just below Abram Bailey's Croton upper rolling mill; went into operation July, 1857.

16. Peekskill Anthracite Steam Furnace, at Peekskill, in Westchester county New York on the Hudson River Railroad, 45 miles from New York, owned by Warren Murdock and others, was started in 1854, 16 feet wide across the bosh and 44 feet high, and remained in blast about a year, averaging about 12 tons a day.

17. Greenwood Furnaces, one charcoal (see Table E, 37) and the other anthracite, one driven by water and the other by steam, stand on the New York and Erie Railroad at Greenwood Station, Orange county New York, 44 miles from New York city, and are owned by Robert P. and Peter P. Parrott, the latter managing the works. Greenwood Furnace No. 2 was started July 1, 1854, 18 feet wide across the bosh by 54 feet high, upon magnetic ore from the Monroe town mines 4 miles east and west of the furnace, and is said to have made 5,000 tons in 1855.

18. Manhattan Anthracite Steam Furnace, at Manhattanville, New York county New York, on the Hudson River Railroad, 6 miles north of the city, owned by Headley, Leffarts, Vanvoorhees & Co. and managed by M. Brock, was built in 1854, 11 feet wide by 40 high, and made about 4,000 tons in 1855, from Champlain magnetic and Hopewell and Amenia brown hematite ores.

19. Boonton Anthracite (water) Furnace, at Boonton Morris county New Jersey, on the Morris Canal, 32 miles via canal and 18 miles via turnpike from Newark, owned by Fuller, Lord & Co. of New York, W. G. Lathrop manager, is 14 feet wide across the bosh and 40 feet high, and made in 1857 6,574½ tons from magnetic ore mined along the canal 6 to 13 miles west of the works.

19.5. Stanhope Anthracite Steam and Water Furnace No. 1, situated with the three following at Stanhope in Sussex county New Jersey, half a mile northwest of the railroad station and on the Morris and Essex Canal, went into blast in 1840. No. 2 and 3 furnaces followed about three years later and all three continued to make iron until 1852 when the explosion of the gas reservoir connected with the experimental furnace No. 4 destroyed the works. All three were between 11 and 12 feet across the bosh, got their steam power in 1845, and used magnetic ore from Irondale, eight miles distant to the east. No. 4 furnace, built to run on Franklinite ore, was 6 or 8 feet wide across the bosh and about 20 feet high, collecting the zinc fumes in large reservoirs at the tunnel head. The experiment made 100 tons of white, lamellar iron and some tons of zinc paint.

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20. 21. 22. Cooper Anthracite Steam Furnaces, half a mile below the village of Philipsburg in Warren county New Jersey, opposite the mouth of the Lehigh at Easton in Pennsylvania, and therefore on the Delaware River, Morris Canal and New Jersey Central Railroad, with full command of the brown hematite mines of the great valley to the north and west and of the rich magnetic ores of Central New Jersey to the east are owned by the Trenton Iron Company, Cooper & Hewitt and others of New York city, and managed by Joseph C. Kent. The three stacks stand in line and use a common blast of great power. Their inside dimensions vary, No. 1 being 20×55, No. 2, 18×42, and No. 3, 22×55 feet high. No. 1 produced, in 1855 7,980 tons; No. 2, in 1856 7,041 tons; and No. 3, in 1855 7,423 tons, running full time. Here the first experiments on this side the water were made in 1856 to test the availability of Bessemer's process for blowing cold air at a high pressure into molten cast iron to produce malleable metal.

23. 24, Durham Anthracite Steam Furnaces, No. 1 and 2, in Bucks county Pennsylvania, nine miles south of Easton, and a short distance up the left bank of Durham Creek from its mouth in the Delaware River, owned by Jos. Geo. P. Jos. R. and Geo. W. Whitaker and W. Davis, were built, the one in 1848, the other in 1851. No. 1 is 13×40, No. 2, 14×40. No. 1 made 5,217 tons in 1856, and No. 2, 5,054 in 1855, working full time. The entrance to the magnetic ore vein, 6 feet thick, is within 300 yards of the works; the brown hematite banks are not much further off, belonging to synclinal fragments of Lower Silurian Limestone (No. II.) engaged between the low ranges of the Highlands, here called the Easton and then the Reading Hills.

25. South Easton Anthracite Furnace (using both water and steam) on the south side of the Lehigh River and between the canal and river, one mile above its mouth at Easton, owned by Chas. Jackson, Jr. of Boston Massachusetts, was built in 1845 and rebuilt in 1853, 14 feet one way and 12 feet the other across the top of the bosh, 48 feet high, and made $4,677\frac{1}{2}$ tons in 1856. It uses the brown hematite deposits at the edge of No. II. Lower Silurian Limestone, on the north side of the Easton or Durham hills, and about a mile south of the Lehigh.

26. 27. 28. The Glendon Anthracite Furnaces, Nos. 1,

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2, 3, situated in the same way one mile higher up than the last, owned also by Chas. Jackson, Jr. of Boston, and managed by Wm. Firmstone, stand together but were built in different years, 1844, '45, and '50, and are of different sizes. No. 2 was originally 10 feet but rebuilt in 1850, 14 feet one way and 12 the other across the bosh, by 45 high. No. 1, 18+14 wide, by 50 high; No. 3, 16+14 wide by 45 high. No. 1 uses water power; No. 2 and 3 use steam and water for a common blast. No. 1 made 6,770½ tons in 1856; No. 3, 6,855, in 1856; No. 2 made in 52 weeks of the same year 5,537 tons. These furnaces use the brown hematite ores found on both sides of the Lehigh River in the Lower Silurian Limestone No. II.

29. 30. 31. 32. The Allentown Iron Company's Anthracite Steam Furnaces, on the west side of the Lehigh River, one mile above Allentown in Lehigh county Pennsylvania and alongside of the Lehigh Valley Railroad, rise together from the river plane, in the grandest and most picturesque style, throwing into the shade many of the castles of Europe. No finer object of art invites the artist. The still huger pile of the Crane Works on the opposite side of the river a little higher up is rendered less striking by the vicinity of the hills; the Allentown Works rise unobstructed and unrivalled by surrounding sights, a world of stone and iron in the air, its summit crowned with tall chimneys like the turrets of Caernarvon, flames issuing from its tunnel heads, and cars travelling up and down its planes, long trains of ore mules passing to and fro across its lofty bridges, while other trains of railroad cars wait below to carry off its iron. The repose of bygone centuries seems to sit upon its immense walls, while the roaring energy of the present day fills it with a truer and better life than the revelry of Kenilworth or the chivalry of Heidelberg. Its archways conceal a perfected alchemy where the spirit of the wind converts earth to iron and dross to gold, condensing around this pile of matter a little world of intellectual and moral happiness and energy to which poets and statesmen might profitably travel to learn more than is read in books or declaimed in Congress.

Two of these stacks are 12 feet wide and two are 16 feet; three of them are 45 feet high and the fourth 50 feet. No. 1 was built in 1846 and No. 2 the following year. No. 3 in 1852 and No. 4 in 1855. In 1856 No. 1 made 4,112 and No. 3

6,850 tons, full time. No. 4 made 6,616 tons in 50 weeks. The furnaces are fed with the brown hematites of the valley dug at various distances within a western semicircle of nine miles. The great valley, across which the Delaware above Easton the Lehigh above Allentown and the Schuylkill above Reading flow, abounds in these local and uncertain but priceless deposits, between the last named rivers, and to reach these the new railroad is being made.

33. 34. 35. 36. 37. The Lehigh Crane Iron Company's Anthracite Steam Furnaces, Nos. 1, 2, 3, 4, 5, stand in one pile, at Catasauqua, Lehigh county Pennsylvania, three miles above Allentown on the opposite or eastern side of the river, on the banks of the canal, and in front of the bridge. David Thomas who introduced the successful anthracite make of iron into this country, first at Pottsville and then here, is still the agent and manager of these great works. He built the first stack in 1840, the second in 1842, added a third in 1846, and the remaining two in 1850. The first three are 47 feet high, but of different bosh widths, namely, 11, 13, and 16 feet. The last two are 18 feet wide by 55 feet high, blown by one great blast cylinder, furnishing each of them with 9,500 cubic feet of air per minute, at a pressure of 5½ lbs. to the inch, and made in 1857, No. 4, 10,122 tons, and No. 5, 10,262 tons of metal in the fifty-two weeks, thus not only reaching but exceeding the yield of the Thomas Iron Company stacks next to be discussed. The ores used at the works are obtained from the brown hematite deposits to the east of the river, mixed with magnetic ores from New Jersey.

38. 39. The Thomas Iron Company's Anthracite Steam Furnaces, Nos. 1, 2, at Hockendauqua Lehigh county Pennsylvania, on the west side of the Lehigh River, at the bridge a mile above the Crane Works, and on the Lehigh Valley Railroad four miles above Allentown, were built in 1855, and are managed by Mr. Thomas & Son, with great success. Built together and alike, 18 feet across the bosh and 60 feet high, and blown by two blast cylinders in common, at the extraordinary pressure of 8½ lbs. to the square inch, these twin stacks have steadily kept in advance of all the other furnaces of the United States. In 1856 they made 17,446 tons together. In 1857 No. 1 produced 9,731¼ tons, and No. 2

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8,366¾ tons of iron. The consummate skill and long experience of the manager must no doubt avoid or redress the ordinary troubles of the process, but this immense production even from these first class stacks can be accounted for only by the enormous consumption of oxygen which they are allowed. It is a satisfactory evidence of the constancy and reliability of the chemical and mechanical laws at our command for making iron that the introducer and oldest producer of anthracite iron in America has not been superseded, but is able still to lead off the greatly enhanced production with these high figures. It is evidently no game of chance, but a trial of practical wisdom based on experience and insured by the improvement of all the means at the disposal of the man. In a word here stands the demonstration that a large and well built crucible, properly stocked with good ores and properly blown with power to spare, must be a great and continual success.

40. The Lehigh Valley Iron Company Anthracite Steam Furnace, B. S. Levan superintendent, Laubachsville, Lehigh county Pennsylvania, on the railroad one mile above the last, was built in the same year 1855, 14 feet wide by 45 feet high, and made, in 1857 4,465 tons of iron in 36 weeks, from brown hematite ore from Balliot's and Brown's banks about 3½ miles west, and from Ritter's and Beisel's banks on the new Fogelville and Catasauqua Railway which is building to connect Allentown on the Lehigh with Port Clinton on the Schuylkill.

41. Poco Anthracite (water) Furnace, so named from the Poco or Pohopoco Mountain and stream to the north of it, stands on the east side of the Lehigh River, on the canal, at the mouth of the Big Creek, 22 miles above Allentown, opposite the Lehigh Valley Railroad station of Parryville, and in the Village of Parryville, Carbon county Pennsylvania. It was built in 1855 and is owned by Bowman, Bros. & Co. lately incorporated as the Carbon Iron Company, Dennis Bowman, president. It is 13 feet wide by 40 feet high, and received new and stronger blast machinery in 1857. In forty-one and a half weeks of 1857 she made 3,217 tons.

42. Mauch Chunk Anthracite Furnace, 9×33, Weiss, Lippencott & Co., W. McDowell manager, Carbon county

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Pennsylvania. The ruins of the old Mauch Chunk or Carbon Furnace built in 1826, form a picturesque object in the gorge of the Second Mountain below Mauch Chunk, with its outhouses and hills of cinder. The machinery has been removed to the new stack, which is built at the upper end of the village of Mauch Chunk, in the narrow red shale valley between the Second Mountain on the south and the Mauch Chunk or Coal Mountain on the north.

43. **Pioneer Anthracite Steam Furnace**, at Pottsville Schuylkill county Pennsylvania, owned and managed by Atkins & Brother, was built in 1837, to try the new fuel anthracite coal in the manufacture of iron. William Lyman, of Boston at that time managed it and Mr. Thomas visited it to blow it in. From want of experience and insufficient machinery the furnace was in constant trouble but perseverance and time overcame one obstacle after another and the Pioneer has become a Settler, making its fair share of iron every year. It was rebuilt in 1854 and is now 12 feet in the bosh by 36 high, and made in 1857 3,849 tons of iron. But the ores of the anthracite coal measures upon which large calculations were based when the furnace was built, have proved to be worthless and the furnace has run upon mixed magnetic and brown hematite ores from the Reading Valley and the South Mountains.

44. **The Leesport Iron Company's Anthracite Steam Furnace** at Leesport in Berks county Pennsylvania, on the Schuylkill Canal and east side of the river, F. S. Hunter agent and T. Cole manager, was built in 1853, 14 feet wide by 45 high, and made in twelve months, 1855, 4,778 tons of metal, out of seven-eighths brown hematite and one-eighth magnetic ores mixed.

45. **Moselem Anthracite Furnace**, on Maiden Creek, seven miles due east from Leesport, Berks county Pennsylvania, owned by F. S. Hunter, and managed by Nicholas Hunter, is 9 feet wide by 34 high, and works up the old South Moselem brown hematite ore, which has been quarried for more than thirty years and supplies Leesport Furnace also with most of its stock. Moselem Furnace, built in 1823, was lately fitted for burning anthracite.

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46. 47. The Robesonia Iron Works, Furnace No. 1 and 2, once called the Reading Furnaces, stand 12 miles west of Reading, half a mile south of the turnpike and 2 miles east of Womelsdorf in Berks county Pennsylvania. Owned by Robeson, White & Co. since 1857, the old stack, $9\frac{1}{2} \times 30$, was built in 1853, the new one, 14×40, has waited for the opening of the Lebanon Valley Railroad in the spring of 1858 to make its first blast. In 1856 No. 1 made 2,141 tons in 48 weeks from Cornwall magnetic ore, brought seventeen miles from the west, on account of its superior cheapness. No. 2 is calculated to make 120 tons of iron per week, of Cornwall ore.

48. Reading Anthracite Steam Furnace, on the Reading Railroad, at the south end of the city of Reading, Berks county Pennsylvania, overlooking the Schuylkill River; owned by Seyfert, McManus & Co.; built in 1854, 18 feet wide by 49 feet high; made in 39 weeks of 1856 5,972½ tons, from mixed magnetic and brown hematite ores.

49. 50. The Henry Clay Anthracite Steam Furnaces, Nos. 1 and 2, on the Reading Railroad, at the south end of the city of Reading, Berks county Pennsylvania, and 54 miles from Philadelphia, are owned by Eckert & Brother, and managed by D. E. Benson. No. 1, built in 1846, 14 feet wide by 38 feet high, made in 49 weeks of 1856 4,018, and No. 2, built in 1854, 15 feet wide, and 38 feet high, made in 46 weeks of 1856 4,729 tons of iron, from mixed magnetic and brown hematite ores.

51. Keystone Anthracite Steam Furnace, at Birdsborough, Berks county, Pennsylvania, on the Schuylkill, 49 miles by railroad from Philadelphia, was built in 1854, is 12 feet across the bosh, and 45 feet high, and made in 1856 3,885 tons of metal, out of two-third magnetic ore from Warwick and Jones's mines, about eight miles south, mixed with one-third brown hematite from the mines near Yellow Springs six miles southwest of Phœnixville.

52. Hopewell Anthracite Steam Furnace is a new stack built upon the Schuylkill Canal, four miles north of the old charcoal furnace, the machinery of which has been removed to the new site; owned by Clingan & Buckley, Hopewell, Berks county, Pennsylvania. The new stack is 12 feet wide

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across the bosh by 36 feet high, and began its first blast in 1857.

53. 54. 55. The Phœnix Iron Works have three anthracite steam furnaces, No. 1, 2, 3, near the rolling mills on the flat at the mouth of French Creek, and on the Reading Railroad and Schuylkill Canal at Phœnixville, Chester county, Pennsylvania, twenty-eight miles from Philadelphia. Owners, Reeves, Buck & Co. of Philadelphia; manager, John Griffin. All three stacks are of one height, 38 feet; No. 1 and 2 are 12 feet in the bosh, and made in 1857 6,425¾ and 5,346¼ tons; No. 3 is 14 feet wide, and made in 1855 4,794¾ tons. Four cylinders produce a common blast. The magnetic and brown hematite ores used mixed come from Centreville, Spring Mills, Yellow Springs, Boyertown Reading and Coxtown, within a radius of forty miles.

56. Montgomery Anthracite Steam Furnace, at Port Kennedy, Montgomery county, Pennsylvania, 21 miles from Philadelphia on the Schuylkill left bank, owned by C. Miller, J. and M. Patterson and T. G. Hollingsworth of Philadelphia, was built in 1854, 11 × 36, but is now 15 feet wide by 42 feet high, and gets some of its ore three miles southwest, and the rest near Whitehorse and Ship Tavern Stations on the Chester Valley Railroad, which traverses a supposed synclinal valley of Lower Silurian Limestone much metamorphosed.

57. Lucinda Anthracite Steam Furnace, at the upper end of Norristown, Montgomery county, Pennsylvania, 17 miles from Philadelphia, on the Schuylkill Canal, owned by William Schall, was built in front of the rolling mill, in 1856, going into blast near the close of that year. It is 11 feet bosh by 34 high, and made in 1857 2,000 tons in 30 weeks. Part of the gas was used in the rolling mill. It mixed about one-twentieth magnetic ore with the brown hematites of the neighborhood.

58. 59. The Swede Iron Company Anthracite Steam Furnaces, No. 1 and 2, form a noble pile, visible from afar, on the plain of the right bank of the Schuylkill, two miles below Norristown and 15 miles from Philadelphia, the stock plains crossing the Reading Railroad has been lately sold to J. B. Moorhead, 1,406 Arch street, Philadelphia; Griffith Jones, manager, Conshohocken P.O. Montgomery county, Pennsylvania. The stacks are each 14 feet wide in the bosh, but

No. 1 is 42, and No. 2, 50 feet high. No. 1 made in 48 weeks of 1856 5,038 tons of metal from the brown hematite ore of the company's banks, one mile west. No. 2 has not been in blast since October, 1855. The double stack, with its lofty round arches, is as fine a study for artists in its way, as the Allentown Works, gaining in effective height what it lacks in width and mass.

60. **Plymouth Anthracite Steam Furnace,** at the east end of the bridge, 13 miles from Philadelphia, on the Norristown Railroad, Montgomery county, Pennsylvania, and owned by Stephen Colwell, of Philadelphia, was built in 1845, 11 feet wide by 36 feet high, and made in 1855 4,016 tons of metal, chiefly out of the brown hematites of the neighborhood.

61. **Merion Anthracite Steam Furnace,** at the west end of the same bridge, owned now by Joel B. Moorhead and managed by S. Fulton, was built three years later (1848), 12 feet wide by 38 feet high, and made in 1856 4,462½ tons.

62. **Springmill Anthracite Steam Furnace,** one mile below Plymouth Furnace, owned by Jno. Farr's heirs and David Reeves, and managed by J. W. Collins, was built a year before Plymouth (1844), is 12 feet wide inside by 40 high, and made, in 49 weeks of 1857 4,511 tons of metal from brown hematite ores.

63. **William Penn Anthracite Steam Furnaces,** No. 1 and 2, near the Springmill Furnace, and also on the Norristown Railroad and Schuylkill Canal, 12 miles from Philadelphia, owned and managed by Hitner, Cresson & Co. Barren Hill, P.O. Montgomery county, Pennsylvania, were built, No. 1, in 1845, 11¾×37 feet high inside, making in 1857 4,264 tons, and No. 2, in 1853, 14×53, making in 1856 5,512 tons of metal, from brown hematite ores.

65. **Safe Harbor Anthracite Steam Furnace,** on the Conestoga Creek Slackwater, east bank of the Susquehanna river, ten miles below Columbia, Lancaster county, Pennsylvania, owned by Reeves, Abbott & Co. of Philadelphia, and managed by Wyatt W. Miller, was built with the rolling mill in 1848, 14 feet across the bosh by 45 feet high, and made in forty weeks of 1856 4,383½ tons of metal out of brown hematite ores, from the Kendig and Rathbone shafts, one hundred and

forty feet deep, and the Gontner surface quarry, all within three miles, and on the southern limit of the great Lancaster county outspread of metamorphosed Lower Silurian Limestone No. II.

66. Conestoga Anthracite Steam Furnace, in the southern part of the borough of Lancaster, C. Geiger owner and manager, was built in 1853, 11×36 inside, and made 3,640 tons in 1856, out of brown hematite ore.

67. 68. Shawnee Anthracite Steam Furnaces, No. 1 and 2, one mile southeast of Columbia, Lancaster county, Pennsylvania, owned by A. and J. Wright, are blown by one apparatus. No. 1, 10 feet wide by 33 feet high inside, was built in 1844, and made 3,304 tons in 1856. No. 2, 14×47, was built in 1853, and made in 43 weeks of 1855 4,356 tons of metal out of brown hematite ores got mostly from banks four miles from York.

69. Cordelia Anthracite Steam Furnace, two miles east of Columbia, Lancaster county, Pennsylvania, and three-quarters of a mile west of the celebrated Chestnut Hill ore bank, from which it gets its stock, is owned by Kauffman, Shaeffer & Co. and managed by C. S. Kauffman, of Columbia. Built in 1848, it is 10¼ feet across the bosh, 35 feet high, and made in 48 weeks of 1857 3,470½ tons of metal out of brown hematite ore mixed with a little grey magnetic from Cornwall near Lebanon. The stack was rebuilt in 1855, and the engine destroyed and restored in 1856.

70. St. Charles Anthracite Steam Furnace, half a mile above Columbia, on the east bank of the Susquehanna Canal and Railroad, owned and managed by Clement B. Grubb, was built in 1853, is 14 feet wide and 45 high inside, and made in 1855 4,530 tons of metal out of brown hematite ore.

71. Henry Clay Anthracite Steam Furnace, two miles above Columbia, on the east bank of the Susquehanna Canal and Railroad, owned by C. B. Penrose & Co., and managed by Mr. Erb, was built in 1845, is 10 feet across the bosh by 32 feet high, and uses brown hematite ore.

72. Chickeswalungo Anthracite Steam Furnace, half a mile above the last, beneath the cliffs of Chicques Rock, a

metamorphosed sandstone near the base of the Lower Silurian Limestone, holding a position analogous to one of the sandstone formations between the Magnesian Limestones of Missouri. The furnace is owned by E. Haldeman & Co. Columbia, Lancaster county, Pennsylvania, was built in 1846, is $10\frac{3}{4}$ feet across the bosh by 32 feet high, and made in 1855 3,209 tons of metal from the brown hematite ores of the neighborhood.

73. **Eagle Anthracite Steam Furnace,** at Marietta, Lancaster county, Pennsylvania, three miles above Columbia, and a half mile above No. 72, on the railroad and canal, is owned by Eagle, Beaver & Co. and managed by Mr. Beaver. It was built in 1854, is 12 feet in the bosh by 35 feet high, and made in 1857 4,332 tons of metal, out of Chestnut Hill brown hematite ore mixed with a little Cornwall grey magnetic.

74. **Donegal Anthracite Steam Furnace,** in Marietta, a hundred yards above the last, and owned by Eckert & Myers, and managed by Mr. Rambler, was built in 1847, is 12 feet wide across the bosh by 35 feet high, and made in 1855 4,747 tons of metal, out of seven-eighths brown hematite ore from its own banks and others within six miles east, mixed with one-eighth Cornwall grey magnetic.

75. 76. **Marietta Anthracite Steam Furnaces,** No. 1 and 2, a hundred yards above the last, owned by Musselman & Watts, were built in 1849 and 1850, 11×36 and 10×30 feet inside, and made in 1857, No. 1, in 43 weeks, $3{,}560\frac{1}{2}$ tons, and No. 2, in $30\frac{1}{2}$ weeks, $2{,}469\frac{1}{4}$ tons of metal out of mixed brown hematite ores from the neighborhood.

77. 78. **Middletown Anthracite Steam Furnaces,** No. 1 and 2, at Middletown, in Dauphin county, Pennsylvania, on the east bank of the Susquehanna, 13 miles above Marietta, and 9 miles below Harrisburg, on the canal and railroad, owned by Wood & Stirling, of Pittsburg, and managed by J. C. Boyle, were built in 1853 and 1854, $12\frac{1}{2}$ feet wide in the bosh. No. 1 is 33 feet high and made in 1856 $3{,}420\frac{1}{2}$ tons. No. 2 is 36 feet high, and made in 34 weeks of the same year, 2,261 tons of metal, out of Cornwall magnetic ore which comes thirty miles down the Union Canal from near Lebanon.

79. **Cameron Anthracite Steam Furnace,** at the east end of the village of Middletown, half a mile from the last,

is owned by Landis & Co. was built in 1856 and furnished with the machinery which blew the two old Cameron Stacks torn down at the same time. The new stack is 14 feet wide across the bosh and 35 feet high, and has made in 38¼ weeks of 1857 2,575 tons of metal out of mixed magnetic and brown hematite ores.

80. Harrisburg Anthracite Steam Furnace, at Harrisburg, Dauphin county, Pennsylvania, on the east side of the canal, back of the capitol, is owned by David R. Porter, and managed by W. Keller, was built in 1845, is 11 feet in the bosh by 40 feet high, and made in 1855 3,805 tons of iron out of mixed grey magnetic and brown hematite ores.

81. Paxton (late Keystone) Anthracite Steam Furnace, on the east side of the railroad, a mile south of the Harrisburg Furnace, is owned by McCormick & Co. (late Bryan, Longenecker & Co.), was built in 1855; is 16 feet wide and 43 feet high inside, and made in 37 weeks of 1855 4,504 tons of metal out of mixed magnetic and hematite ores, in the proportion of one-half Chestnut Hill, one-fourth Haldeman, and one-fourth Cornwall. The maximum yield one week was 170 tons.

82. Union Deposit Anthracite Steam Furnace, on the Union Canal in Dauphin county, Pennsylvania, eleven miles east of Harrisburg, is owned by Gingrich, Balsbaugh & Co. S. M. Krauser agent, was built in 1854, is 11 feet wide by 39 high inside, and made in 36 weeks of 1857 2,294 tons of metal from Cornwall grey magnetic ore, which comes 14 miles down the Union Canal from Lebanon.

83. New Market Anthracite Steam and Water Furnace, 3 miles northwest of Millerstown, between Harrisburg and Lebanon, Lebanon county, Pennsylvania, is owned by Light and Early, was built in 1855, is 9×30 feet inside and made in 18 weeks of 1856 728 tons of metal from Cornwall grey magnetic ore.

84. Dudley Anthracite Steam Furnace, on the turnpike half a mile west of Lebanon, Lebanon county, Pennsylvania, is now owned by R. W. Coleman, was built in 1855, is 13½ feet across the top of the bosh and 36 feet high, and made in 39 weeks of 1856 3,628 tons of metal from Cornwall grey magnetic ore, brought by railway six miles from the south.

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85.86.87. North Lebanon Anthracite Steam Furnaces, Nos. 1, 2 and 3, one mile north of the last, on the north side of the Union Canal, are owned by Geo. Dawson Coleman, and managed by Charles B. Forney. No. 1 and 2, were built in 1848 and 1849, side by side with the foundations of a third stack not yet built, and 35 feet high. No. 1 is 14 feet across the bosh and made in 1856 4,602 tons. No. 2 is 12 feet and made in 54 3,688 tons of metal out of Cornwall grey magnetic ore. No. 3 is an experimental stack, 4 feet across the hearth, 10 across the top of boshes, and so up for 26 feet to a tunnel head of the same width; it is stocked by an air blast lift, consisting of a boiler plate tube 50 feet long and 3 feet in diameter, rising and falling vertically in a 5 feet wide well, 52 feet deep, provided with friction rollers on the sides, and filled with water. A small blast tube from the air reservoir descends the side of the well to the bottom, turns and ascends in the centre of the boiler plate tube to the level of the soil. By turning on the blast through this pipe, the boiler plate tube is inflated, and rises like a gasometer with a platform on its head, carrying up the wheelbarrows of ore, coal, and lime to a level with the tunnel head. This plan of hoist has proved entirely successful in England.

But the essential peculiarity of this furnace consists in its using hot blast (if desirable) without robbing the tunnel head of its gas, or interfering with the action of the upper part of the crucible. The hot pipes are therefore heated like the steam engine boiler flues, by the direct application of fresh coal, and the wide tunnel head becomes possible, so soon as the necessity for drawing off the gas at the tunnel head is obviated, and this is the prime object of the experiment.

88.89. Cornwall Anthracite Steam Furnaces, No. 1 and 2, five miles south of Lebanon, Lebanon county Pennsylvania, and near the celebrated Cornwall grey magnetic ore mines, at the north edge of the New Red Sandstone (or Middle Secondary) deposit, where it overlaps the Lower Silurian Limestone and Sandstone, No. II. and I. and near a trap dyke, at the highest source of the Quitapahilla creek,—are owned by R. W. and W. Coleman, and managed by B. Mooney. No. 1, built in 1850, is 12 feet wide in the bosh by 38 feet high, and made

about 5,000 tons in 1856. No 2, built in 1855, is 14 by 38, and produces in the same proportion.

90. Stanhope Anthracite Steam Furnace, two miles from Pinegrove in Schuylkill county Pennsylvania, on the Swatara river, was built in 1835, is owned by Breitenbach and Sheetz, was formerly 11, is now 10 feet wide in the bosh by 33 feet high, and made in 30 weeks of 1856, 1,874 tons of metal from Cornwall grey magnetic ore.

91. Duncannon Anthracite Steam Furnace, at the mouth of Sherman's Creek in Perry county Pennsylvania thirteen miles above Harrisburg, on the west side of the Susquehanna, and on the Pensylvania Railroad and State Canal, was built in 1853, is owned by Fisher, Morgan and Company, is 14 feet wide across the bosh and 40 feet high, and made in 26 weeks of 1854 1,871 tons of metal from mixed grey magnetic, brown hematite and red fossil ores.

92. Lewistown Anthracite Steam Furnace, on the Juniata river and Canal at Lewistown, Mifflin county Pennsylvania, owned by Etting, Graff and Co. and managed by William Willis, was built in 1846, is 11 feet wide and 37 high inside, and made in 44 weeks of 1854 3,486 tons of metal from mixed brown hematite and the fossil red ore of the Upper Silurian Limestone shales of the Clinton group, Formation V. which outcrops along the base of Jack's Mountain.

93. Hope Anthracite Steam Furnace, two miles back from the Juniata river canal, seven miles above Lewistown, Mifflin county Pennsylvania, was built in 1810. It is now owned by J. Murray of Baltimore, A. R. Wood and others; is 12 feet wide by 39 high inside, and made 900 tons in 16 weeks in 1856 from mixed brown hematite and fossil ore like the last.

94. Shamokin Anthracite Steam Furnace, at Shamokin, Northumberland county Pennsylvania, on the Shamokin and Sunbury railroad. It is in the same position relative to the exit of the Shamokin river through the gap in the northern barrier of that Anthracite coal-field, as that occupied by Pioneer Furnace (No 43) relative to the Sharp mountain gap at Pottsville. These are in fact the only two anthracite furnaces built upon coal rocks, in the southern basins; a fact to be explained by the

entire absence of available beds of iron ore in the Anthracite coal measures, and the mountainous and still inaccessible character of most of the region which they occupy. It is of course easier to run down the coal to the neighborhood of the ore beds than to drag the ores up into the coal. The absence of limestone in the eastern coal fields is also an element in the arrangement. Shamokin Furnace, owned by H. Longenecker, and Co. and built in 1842, is 12 × 45 inside, brings its ores from Lebanon, Columbia and Danville, and made in 32 weeks of 1856, 2,465 tons.

95. Chulasky Anthracite Steam Furnace, in Northumberland county Pennsylvania, standing under the cliffs on the north bank of the North Branch Susquehanna, three miles down the canal from Danville, Montour county Pennsylvania, was owned by one of the pioneers of Iron Manufacture in America, Samuel Wood of Philadelphia, until his death in 1857. It is now owned by J. V. L. Dewitt and managed as before by R. W. Richardson; is 15 feet wide across the bosh and 42 feet high, (reduced 8 feet in 1856,) and produced in 51 weeks of 1857 4,645¼ tons of metal from red fossil Upper Silurian or Clinton ore of Formation V. cropping out all around Montour's Ridge.

96. Franklin Anthracite Steam Furnace, three miles northwest of Danville, in Montour county and behind Montour's Ridge, owned by David Reeves and Son, was built in 1846 and stands idle since 1855. It is 9 × 32 inside and made in 1854 1,660 tons from red fossil ore of Formation V.

97. 98. 99. The Montour Iron Company's Anthracite Steam Furnaces Nos. 2, 3 and 4 stand together at the lower or western end of Danville, on the North Branch Canal and near the Catawissa and Williamsport railroad, and are managed by J. P. and J. Grove. No. 2 and 3 were built together in 1839 and are 17 feet wide across the bosh, 35 feet high and 10 feet across the tunnel head, and made in thirty-seven and thirty-nine weeks of 1857 5,517 and 5,361 tons. No. 4 was added in 1846, 14 by 35, with a tunnel head at first 7 and then 13 feet wide, and made in thirty-seven weeks of the same year, 3,371¼ tons of metal. In 1856 No. 1 used only the red fossil Upper Silurian (Clinton shale) ore of the neighborhood, some of which is a hard silicious block ore and the rest a soft, spongy, ochreous

hematite originally full of minute limestone fossils; No. 3 mixed one half Cornwall grey magnetic ore, and No. 4, one third. The great rolling mill works of the company are near by, see Table G. No. 90. The Rough and Ready Mill, Table G. No. 89, is also in the town.

100. Columbia Anthracite Steam Furnace, half a mile from the last at the upper end of Danville, Montour county Pennsylvania, owned and managed by J. P. and J. Grove, was built in 1840 as a bank furnace, had its tunnel head enlarged in 1856 from six to ten feet, is 36 feet high, a straight cylinder 12 feet wide for twenty feet above the bosh, and made in forty-nine weeks of 1857 3,371¼ tons of metal out of mixed Cornwall grey magnetic and Danville red fossiliferous ores.

101. Roaring Creek Anthracite Water Power Furnace at the mouth of Roaring Creek, Montour county Pennsylvania, on the south side of the Susquehanna, four miles above Danville, owned by Elisha Reynolds and Brother of Danville, and leased by Wm. Kase, was built in 1840 and altered in 1854 from 8 to 10 feet in the bosh by 30 high, received a new hot blast and made in 1856 2,350 tons in spite of low water, out of the red fossil ore of the opposite Montour's Ridge.

102. Bloom Anthracite Steam Furnace, back of Blooms burg, Columbia county Pennsylvania, ten miles east of Danville, owned by McKelvy and Neal, was built in 1847, is 14 feet wide by 50 high inside and made in 1857 5,793½ tons of metal from the red fossil ore of Montour's Ridge, opened in an anticlinal arch on both sides of the gap behind the town, as well as east and west towards Berwick and towards Danville. The ore is in several strata, lapping against the flanks of the Ridge all round. The lower layers are more silicious and the upper more calcareous. The furnaces which run upon this ore get their flux from the Helderberg Limestone Formations, Formation VI. overlying the shales which contain the ore, Formation V.

103. 104. Irondale Anthracite Water Power Furnaces, Nos. 1 and 2, near the last, on the line of the West Branch Valley Railroad constructing from Pittston to Catawissa, are owned by the Bloomsburg Railroad and Iron Company, and managed by Charles R. Paxton, Jr. were built in 1844, 14 feet

wide across the top of the bosh and 35 feet high, No. 1, reduced to 12 feet made in 1857 5,830½ tons, and No. 2 6,161½ tons, out of the red fossil ore of the Ridge.

105. Henry Clay Anthracite Steam Furnace in the middle of the village of Lightstreet, Columbia county Pennsylvania, three miles north of Bloomsburg, owned by Samuel Bettle, built in 1847, 9 feet wide and 32 feet high inside, made in forty weeks of 1854 1,682 tons of metal out of red fossil ore mined on the north side and east end of Montour's Ridge a mile from the Furnace.

106. Williamsburg Anthracite Steam Furnace at the upper end of Lightstreet half a mile north of the last, owned by M. McDowell, built in 1845, 8 feet wide and 28 high inside, has made nothing since 1855, before which time its annual production was about 1,200 tons.

107. Hunlach's Creek Anthracite Steam Furnace at the mouth of the creek, in Luzerne county Pennsylvania, on the north side of the Susquehanna river and North Branch Canal and new Railroad, twelve miles below Wilkesbarre, owned by William Koons of Schickshinny Luzerne county Pennsylvania, was built in 1854, 11 feet wide by 40 high inside, and made in two-thirds of 1857 about 1,900 tons of metal out of Bloomsburg red fossil Upper Silurian, Formation V. ore.

108. The Wyoming Iron Company's Anthracite Steam Furnace half a mile southwest of Wilksbarre, Wyoming county Pennsylvania, on the North Branch Canal, was built in 1847 and burnt August 1855 ; its ruined stack measures 9 feet across the bosh by 32 feet high and the year its machinery was destroyed it made 966 tons of metal from fossil ore. It stands in the heart of the Wyoming coal basin but must draw all its ores from Blossburg and Danville.

109. 110. 111. 112. The Lackawanna Iron and Coal Company's Anthracite Steam Furnaces, Nos. 2, 3, 4, 5, stand together under the lofty bank of the Creek at Scranton, Luzerne county Pennsylvania, in the centre of the eastern division of the Wyoming coal basin, where it is crossed by the Delaware Gap, Scranton and Great Bend, North and South railroad, and with railroad connections along the basin, with Wilksbarre

seventeen miles on the one hand and with Carbondale on the other. L. T. Scranton President. Theodore Sturgiss Treasurer. James H. Phinney Secretary. Joseph H. Scranton General Superintendent. J. C. Pratt Agent. The original No. 1 furnace is a ruin a few paces distant up the creek towards the Rolling Mill, see Table G, 88. No. 2, and 3, were built in 1849, No. 3 was added in 1852 and No. 4 in 1854 but never has been used. Their respective diameters inside at the tops of the boshes are 15, 17, 18 and 20 feet, and their common height 48 feet. Their rate of production has been very unequal. No. 2 made 3,337 tons in six months in 1856. No. 3 made 3,680 tons in forty-three weeks of 1854. No. 3 made 4,536 tons in forty-nine weeks of 1856. The capacity of No. 4 has not been tested. The ores for these stacks are not furnished by the coal measures in which they stand, but are obtained from the red fossil mines of Bloomsburg and Danville, and the magnetic ore-beds of New Jersey. The Anthracite coal measures hold no workable deposits of iron, differing in this greatly from the Bituminous coal measures as we shall see hereafter, although they are not only similar formations but identical in point of origin and age. It is a common fault of English writers to make the anthracite beds older and place them beneath the bituminous, but no doubt of their common age and position is now felt in this country. It has in fact been fully demonstrated. The absence of anthracite iron deposits becomes a subject of curious speculation as it has been one of great pecuniary interest and was a bitter disappointment to the first manufacturers of iron with stone coal. It is an absence however perhaps more practical than real, for the hardening of all the anthracite shales make the same quantity of iron in them as would be workable, were they as soft as they are in the west, inaccessible by ordinary mining and at the ordinary price of iron. Strange at first as it may appear therefore these Lackawana stacks, the Pioneer at Pottsville and the Shamokin, are all that run within the limits of the Anthracite basins of Pennsylvania.

113. Union Anthracite Steam Furnace, four miles below Lewistown, Union county Pennsylvania, on the west side of the West Branch Susquehanna river, owned by Beaver, Geddes, Marsh & Co. of Lewistown, built in 1854, is 15 feet across the

bosh by 45 feet high, and made in forty-five weeks of 1856 3,590½ tons of metal from Cornwall grey magnetic ore mixed with Danville red fossil.

114. Margaretta Anthracite Steam Furnace at the north end of the Sunbury and Erie railroad bridge over the North Branch Susquehanna half a mile below Williamsport Lycoming county Pennsylvania, owned by Bingham, McKinney & Co. and managed by Mr. Kremer, was built in 1855, 13 feet wide by 38 high inside, and made in twenty weeks of 1856 750 tons of iron out of mixed brown hematite and Bloomsburg red fossil ores. The furnace was rebuilt in 1857 and will use block ore from a quarry nine miles west of the furnace, and others along this last outcrop of the same upper Silurian, Clinton, red fossil ore of Formation V. which here disappears beneath the Alleghany Mountain rocks to appear again along the southern shore of Lake Ontario. From Williamsport its outcrop ranges southwestwardly along the northern base of the Bald Eagle mountain, up the Susquehanna to the next furnace, Millhall, and so on to the coke furnaces at Hollidaysburg and Cumberland.

115. The Mill Hall Iron Company's Anthracite Water-power Furnace near the mouth of the Bald Eagle Creek, in Clinton county Pennsylvania, was originally a charcoal furnace built in 1830, and remodelled in 1857, 10 feet in the bosh by 32 feet high, to run on the brown hematite ores of the Nittany Valley Lower Silurian Limestone, Form II. mixed with the Upper Silurian red fossil ores of the Bald Eagle mountain, Formation V.

116. 117. Rough and Ready Anthracite Steam Furnaces No. 1, 2, at Havre-de-Grace, Harford county Maryland, where the Philadelphia and Baltimore railroad crosses the Susquehanna river, owned by Joseph and George P. Whitaker of Philadelphia, were built of the same size 9 feet across the bosh by 30 feet high. No. 1 made 1,265 tons of metal in twenty-one weeks of 1856, out of brown hematite ores mixed with some red fossil, some grey magnetic, and some of the "bone" carbonate ores of the tertiary formations in the neighborhood.

118. South Baltimore Anthracite Water-power Furnace, on the south side of the harbor of Baltimore, Maryland, owned by Daniel M. Reese and managed by the owner, was

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built 10 feet in the bosh by 33 feet high, and made in thirty-eight weeks of 1856 2,600 tons of metal, from brown hematite ores. "On account of the gradual upward tendency in the price of wood, and increasing scarcity of what is termed Baltimore ore, we look for a reduction rather than an increase in the production of pig iron in this city and vicinity. The ores commonly termed bone and chocolate are found embedded in clay in a region of country extending in a northeast and southwest direction, from the Schuylkill to the Potomac, and west or inland to a distance of ten or twenty miles. They were worked before the revolutionary war. Sometimes they are found in a transition state between wood, or the remains of trees, and ore." (Stickney & Co.)

119. The Ashland Iron Company's Anthracite Steam and Water Furnaces, on the Northern Central railroad fifteen miles from Baltimore, Richard Green of Cockeysville, Baltimore county, Agent, are 11 feet across the top of the bosh by 32 feet high. No. 1 made 2,573½ tons in thirty-four weeks of 1854. No. 2 made 4,215 tons in 1856, out of brown hematite ores mixed with some magnetic and some carbonate.

120. Oregon Anthracite Steam Furnace, three miles west of the last and under the same ownership and management, is 11×36 inside, and made 4,419½ tons in 1855.

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TABLES B. E. H. K.

CHARCOAL BLAST FURNACES IN THE UNITED STATES.

1. The Katahdin Iron Company's Charcoal Furnace, Piscataqua county Maine, about fifty miles north of Bangor, near the Iron Mountain, where Pleasant river leaves the Lake, in township vi., range ix., is owned by David Pingree, of Salem, Massachusetts, was built in 1845, 42 feet high, and made in 1856 2,100 tons of metal from bog ore found upon the mountain-side.

2. Franconia Charcoal Furnace in Franconia county New Hampshire is old and has not been in active operation for some years. It used the metamorphic (Upper Silurian or Devonian ?) rock-ores belonging to the White Mountain range.

3. Tyson's Charcoal Furnace, a few miles north of Ludlow, Windsor county Vermont, a railroad station 25 miles east of Rutland on the way to Bellows Falls, is an old furnace owned by Isaac Tyson jun. of Baltimore Maryland, and not in operation. It is upon the eastern slope of the Green Mountains, and has used the metamorphic rock-ores of that side, the brown hematite deposits being on the western slope.

4. The Green Mountain Iron Company's Charcoal Hot-blast Furnace, 3½ miles northeast of Brandon Village, Rutland county Vermont, 17 miles north of Rutland, on a stream at the upper end of Forestdale Village, under Mr. Royal Blake's, house, is quite old, but was enlarged in 1854 to 9 feet across the bosh by 24 feet high, and blown without success with anthracite coal,* and was abandoned in 1855. The Company now own part of the brown hematite Conant deposits, lying about a mile south of the furnace. A bed of red oxide, 3 miles northeast was also used some little to mix. Another brown hematite bed lies 2½ miles north.

Besides these, there have been no blast-furnaces running in Vermont for some years. There stand two in Sheldon, Franklin county, 9 miles east of St. Alban's; one in Troy, Orleans county; two in Bennington, Bennington county, and two in Dorset, on the Western Vermont Railroad, between Bennington and Rutland. The heavy snows make it difficult to get stock, and unless such lignite beds as the one used by Conant Furnace be discovered elsewhere the dearness of charcoal and the scarcity of ore will prevent this from becoming a principal furnace district again.

5. Conant Charcoal Cold-blast Furnace, owned by the Brandon Iron and Car Wheel Company, George W. Palmer

* Not noticed in the Anthracite table.

treasurer and agent, in Brandon village Rutland county Vermont, on Mill River, quarter of a mile north of the railroad depot, 17 miles north of Rutland, and 50 south of Burlington, was built in 1820 and rebuilt and enlarged in 1839 to 8 feet in the bosh by 39 feet high, and made in twenty-one weeks of 1855 1,144 tons of car-wheel iron, out of brown hematite ores from the banks 2 miles east of the village at the foot of the mountain. This is a locality of great geological interest. With the iron ore is deposited oxide of manganese, kaoline or porcelain clay, and lignite brown coal containing multitudes of fossil fruit, figured and described by Prof. Hitchcock in *Silliman's Journal*, January 7, 1853, and supposed by him and by some other geologists, to demonstrate the tertiary age of all the brown hematite beds referred to in these notes, and found distributed along the narrow belt of limestone country from Canada to Alabama; a mistake which will be discussed fully hereafter. The company which works this ore bed and runs the furnace was incorporated in 1851 with an ultimate capital of $150,000. It manufactures car-wheels, fire-brick, paints and paper-clay in Brandon. It has also a foundry and machine shop in Rutland, 300 yards from the railroad station. This furnace is run with the lignite coal found in the ore quarry.

6. The Pittsford Iron Company's Charcoal Hot-blast Furnace, three miles east of Pittsford, Rutland county Vermont (a village station nine miles north of Rutland on the Vermont Central Railroad and ten miles south of Brandon furnace), managed by Mr. Granger, Pittsford Furnace P.O. was built as long ago as 1791, rebuilt in 1824, 8×27, and enlarged in 1853 to 9 feet across the top of the bosh by 42 feet high. This beautiful stack standing at the mouth of one of the western ravines of the Green Mountains is built of stone taken from one rock and round-arched over the tuyères with fire-brick, has a water-wheel of 24 feet, and made in thirty weeks of 1856 1,569 tons of iron, out of the brown hematite ores of the vicinity (in Lower Silurian metamorphosed Limestone For. II.) mixed with a little Champlain magnetic ore. A foundry is attached to the furnace manufacturing 300 tons of stoves per annum.

7. Dorset Charcoal Furnace, at Dorset in Bennington county Vermont, is old, and has been active until lately, work

ing up the brown hematite ores of the same Lower Silurian Limestone belt which faces the Green Mountains on the west.

8. The North Adams Iron Company's Charcoal Hot-blast Furnace, on the Hoosic river, J. E. Marshall agent, North Adams P.O. Berkshire county Massachusetts, was built in 1845, is 8 by 31 inside and made in forty-five weeks of 1856 1,916 tons of iron for the Albany Iron Works, out of brown hematite from the Adams' bank 2½ miles southwest, mixed with Lanesborough (14 m. south), Richmond and Amenia ores.

9. The Cheshire Iron Furnace Company's Charcoal Warm-blast Steam Furnace, managed by E. W. Thayer, Cheshire P.O. Berkshire county Massachusetts, was built in 1848, about 9 feet across the bosh by 40 high, and made in half of 1856 686 tons of metal out of brown hematite ore from its own banks east and west of it within a mile.

10. The Briggs Iron Furnace Company's Charcoal Warm-blast Steam Furnace, in Lanesborough, Berkshire county Massachusetts, 5 miles west of Pittsfield, and 1½ miles across a mountain west of the North Adams railway, Daniel Day treasurer and agent, was built by Samuel Smith of Boston in 1847, is 11¼ feet wide by 42 feet high, and made in twenty six weeks of 1857 1,098½ tons of soft iron for Worcester, Springfield, Lawrence and Boston, out of brown hematite ores from its own banks 3½ miles west. It commenced making hot-blast iron in 1848.

11. The Lenox Iron Works Company's Charcoal Hot-blast Furnace, W. A. Phelps treasurer and agent Lenox P.O. Berkshire county Massachusetts, was first built as long ago as 1765, 28 feet high with one tuyère. In 1839 it was rebuilt, $9 \times 35\frac{1}{3}$, with 3 tuyères, and made in forty-two weeks of 1857 1,772¾ tons of strong foundry metal for Pittsfield, Springfield, Worcester, Boston, Stafford, and Troy., out of brown hematite ore from its own bank, 4 miles west. This furnace made in the good year 1851 2,081 tons.

12. The Stockbridge Iron Works Company's Charcoal Furnace, No. 1 (No. 2 is anthracite, see table A. No. 3), situated three miles from Stockbridge village and one mile from the Housatonic post office, R. Ray agent (G. B. Cartwright agent

in Boston), was built in 1835, is 10 feet wide across the top of the bosh, and made until 1855 when it stopped about 1,200 tons in thirty-five weeks per annum.

13. The Richmond Iron Company's Charcoal Warm-blast Steam and Water Furnace, on the Western railroad, five miles northeast of the State Line, and eight miles southwest of Pittsfield, John H. Coffin agent, Richmond P.O. Berkshire county Massachusetts, is 9 feet in the bosh by about 31 feet high, and made in forty-three weeks of 1856 2,242½ tons of hard carwheel iron, which stood a strain of 24,222 lbs. to the square inch, out of brown hematite ores from the Richmond and West Stockbridge mines owned by the Company.

14. The Vandusenville Charcoal Hot-blast Furnace, at the junction of the Pittsfield and the Albany branches of the Housatonic railroad and two miles and a half from Great Barrington, owned by the same Richmond Iron Company as the last, was built in 1834 and rebuilt in 185?, is 9 feet wide across the bosh by 32 feet high, and made in forty-one weeks of 1855 2,395¼ tons of mostly hard car-wheel metal out of brown hematite ore from the Richmond bank ten miles, and the West Stockbridge bank seven and a half miles north of the furnace. Steam power was to have been given to it in 1857.

15. Beckley Charcoal Hot-blast Furnace, in East Canaan, Litchfield county Connecticut, two miles east from North Canaan Station on the Housatonic railroad, owned by John A. Beckley, John Dunmore agent, run by Richardson, Barnum & Co. in 1857, was built in 1847, is 9 feet wide by 30 high inside, and made in fifty weeks of 1857 2,704 tons of mostly car-wheel iron for Albany, Troy and Schenectady, Canada and Georgia, out of brown hematite ores from Salisbury, Old Hill and Davis' banks.

16. The Forbes' Iron Company's Charcoal Hot-blast Furnace, near the last is older, having been built about 1832. Rebuilt and remodelled in 1856, it is now 9 feet wide by 28 feet high within and made in thirty-nine weeks of 1857 1,858¼ tons of metal, out of the same ores as the last.

17. Scovill's Charcoal Hot-blast Furnace, in South Canaan Litchfield county three miles east of Falls Village

B

Housatonic railroad station, owned by Scovill & Co. Falls Village P.O. Litchfield county Connecticut, built as cold blast in 1844 and changed to hot blast about 1853, is 8 feet wide by 25 feet high inside, and made in thirty-two weeks of 1857 1,142 tons of iron, out of brown hematite ore from its own bank ten miles west, and Old Hill and Davis' banks nearly as far.

18. **Buena Vista Charcoal Hot-blast Furnace,** five miles east of Falls Village Housatonic railroad station, owned by Hunt, Lyman & Co. managed by D. M. Hunt, Huntsville, Litchfield county Connecticut, built in 1847, is now 10 feet wide across the top of the bosh by 29 feet high inside, and made in forty-four weeks of 1856 2,015¾ tons of high grey car-wheel iron for the Jersey City Car Works and elsewhere including Rochester, Buffalo and Wilmington Delaware, out of brown hematite ore from the same banks mentioned in the last.

19. **The Cornwall Iron Company's Charcoal Cold-blast Furnace,** near the Housatonic railroad station in West Cornwall, (Samuel Scovill agent, West Cornwall P.O. Litchfield county Connecticut,) built in 1832, is 8½ by 30 feet inside, and made through the blast of 1856 27 tons of metallic grey iron a week, roasting its brown hematite Amenia and Salisbury ores with its hot gases passed through the piles of ore in the yard. This plan has been successfully employed since 1854.

20. **The Cornwall Bridge Iron Company's Charcoal Cold-blast Furnace,** near the Housatonic railway station of that name in West Cornwall Litchfield county Connecticut, was built in 1833, never used but one tuyère, is 9 × 30 feet inside, and made perhaps 1,200 tons in 1854, of malleable iron for the city markets, out of brown hematite ores.

21. **Mount Riga Charcoal Cold-blast Furnace,** five miles north of Lakeville, once called Furnace Village, was formerly owned by Campbell of Millerton, now by the Salisbury Iron Company, Landon & Co. Chapensville Litchfield county Connecticut, was an old furnace, built about 1800. It was rebuilt in 1845 8 feet across the top of the bosh by 30 high, but across the bilge six feet above the top of the bosh it is 16 feet wide. It made in fourteen weeks of 1856 436 tons of forge iron out of brown hematite ore from the Old Hill mine, a deep pit

quarry yawning beneath the main road from Millerton to North Canaan and Hartford, one of the oldest and largest of all this curious range of deposits in the Lower Silurian metamorphic belt on the northwest side of the Highlands of New York, Connecticut, Massachusetts and Vermont. Davis' banks lie one and half mile further east near Lakeville.

22. Joiceville Charcoal Furnace, one and a half mile northwest of the next to be described and only used when that has an excess of stock, is known also as the Sage Iron Company's Furnace. Owned by Landon and Co. and the Salisbury Iron Company, Chapensville P.O. Litchfield county, Connecticut, it is about 8×29, and has stood idle since 1854.

23. Chapensville Charcoal Cold and Hot blast Furnace, three and a half miles north-northwest of Falls Village Housatonic railroad station, and a mile north of the main Hudson and Hartford road through Millerton, is owned as the last, and of the same size, and made in thirty-five weeks of 1856 1,155 tons of partly hot partly cold-blast iron from Old Hill hematite ore.

24. Limerock Charcoal cold blast Furnace, three miles west-southwest of Falls Village Housatonic railway station, owned by Canfield and Robbins of Falls Village, Salisbury, Litchfield county. Connecticut. Built about 1825, $8\frac{1}{2} \times 30$, furnished with a hot-blast apparatus which it never used but once and then scarcely warm, it made in twenty-two weeks of 1856 205 tons of forge iron for the Falls Village works. Limerock is a very old iron locality. Here iron was made 120 years ago by bloomery forges running upon Old Hill bank ore. There is an old furnace also at Falls Village which has not blown for 17 years. At Lakeville there was one, now torn down, which made iron before the revolutionary war. Shot and shell were cast there for the British troops. The iron for the Albany Water Works was also made there forty years ago. There were two Refining Forges with 10 fires, one at Limerock and the other at Falls Village, which made government iron; but a superior sample of Swedish iron induced government to import largely; and before the inferior imported iron was used up the forges had been abandoned and have since been torn down, and very little refining is now done. Richardson,

Barnum and Co. at Limerock, melted 11 tons, and made 40 car-wheels a day last year, and make this winter 20 a day. In the spring and fall they make 40 a day.

25. Weed's Hot and Cold-blast Charcoal Furnace, four miles east of the Harlaem R. R. Sharon Station on the road to Cornwall, owned by Hiram Weed of Sharon Village, Litchfield county Connecticut, is 7 × 24 feet inside and made about 500 tons in six months of 1855, out of Salisbury, Amenia and Palmer brown hematite ores, for New Haven, Newark and New York.

26. Sharon Valley Cold and Hot-blast Charcoal Furnace, two miles east of Harlaem R. R. Sharon Station, 1½ miles from the last furnace, owned by H. Landon and Co. Fitch and Landon Agents, Sharon Valley Furnace P.O. Litchfield county Connecticut, is 8 × 34 inside, and makes axle and tyre iron for Ames's Works at Falls Village and Eddie's Works at Troy. It made in forty-eight weeks of 1854 1,867 tons of "strong iron," out of the brown hematite ores of the neighborhood. It makes cast iron for government ordnance.

27. Kent Hot-blast Charcoal Furnace, one mile north of the Housatonic R. R. Kent Station, owned by Stewart, Hopkins and Co. Kent P.O. Litchfield county Connecticut, was built originally in 1825, cold blast and 28 feet high. In 1846 it was rebuilt 9 × 31 inside, made hot blast, and uses one-fourth anthracite * coal to supply the deficiency of charcoal. It made in six months of 1856 763 tons of mostly grey iron, out of brown hematite ore from its own mines six miles southeast, mixed sometimes with Kent and Amenia ores.

28. Macedonia Warm-blast Charcoal Furnace, two miles west of the village of Kent, owned by C. Edwards, M. Furnace Litchfield county Connecticut, built in 1826, was made hot blast ten years ago, and uses anthracite † and charcoal half and half. It is 9 feet across the bosh by 30 feet high inside, and made in twenty-two weeks of 1854 and 1855 about 800 tons, out of brown hematite ore from the Amenia bank about ten miles distant by the road.

* Not inserted in Table A. † Ditto.

B

29. Copake Hot-blast Steam Charcoal Furnace, owned by W. L. Pomeroy and Co. Copake P.O. Dutchess county New York, situated three hundred yards southeast of the Harlaem R. R. Copake Station, 46 miles from Albany, 17 miles north of Sharon Furnace, was built in 1845, is 8½ feet wide across the bosh, and 32 feet high inside, and made in forty-one weeks of 1854 1,556½ tons of principally car-wheel iron out of brown hematite ore dug close by the station. This Furnace uses a cone or "trémie" let down 4 feet into the tunnel head.

30. Northeast Hot and Cold-blast Steam Charcoal Furnace, owned by Mr. Dagon of Millerton, Dutchess county New York, situated ten and a half miles south of the last furnace, one mile east of the Harlaem railroad, and one and a half northeast of the Millerton Station, was built in 1847, eleven feet, but is now 8 feet across the bosh by 32 feet high inside, blows principally cold, and made in twenty-eight weeks of 1855 about 940 tons of forge iron, out of brown hematite ore from its banks close by. It uses a cone (*trémie*) 3 feet deep.

31. Benedict's Hot and Cold-blast Charcoal Furnace owned by Benedict and Co. Millerton, Dutchess county New York, situated one mile west of the last and on the west bank of a cutting for the Harlaem R. R. one mile north of Millerton Station, was built in 1854 9×27 feet inside, and made in thirty-two weeks of 1855, 993¼ tons of forge iron, out of brown hematite ore from the Salisbury bank two and a half miles east. This furnace was to be made to run upon anthracite.*

32. Amenia Hot and Cold-blast Charcoal Furnace owned by Mr. Gridley, Wasaic P.O. Amenia, Dutchess county New York, situated at the Harlaem R. R. Wasaic Station, was built in 1825, thirty-three feet high, is now 8 by 30 inside and made in thirteen weeks of 1857 471 tons of best gun-barrel iron, out of brown hematite ore from Amenia bank close by.

33. Dover Hot-blast Charcoal Furnace, owned by the Novelty Works, New York, L. S. Dutcher & Co. lessees, South Dover P.O. Dutchess county New York, is situated at the Harlaem Railroad Dover Station, on its east side, was built in 1835, is 8 feet across the bosh by 32½ feet high inside, uses sometimes

* Not inserted in Table A.

from 70 to 200 lbs. of anthracite coal * to a charge, never runs cold, and makes about 600 tons of chiefly machine iron in the half of the year during which it runs, out of brown hematite ore principally from Amenia bank. Quaker-hill bank is 5 miles southeast and Clove-hill bank 7 miles west.

34. White's Dover Hot-blast Charcoal Furnace, owned by William White of Dover Plains, Dutchess county NewYork, is situated four miles south of the Harlaem Railroad Dover Plains Station, one mile northwest of Dover Furnace Station, in a notch of the mountain one-third of a mile west of the railroad, was built in 1846, is 8 by 32 feet inside, uses one fourth * anthracite, and made in 1853 1,326 tons of principally foundry metal out of brown hematite ore from the Foss bank two miles southwest.

35. Beekman's Hot-blast Charcoal Furnace, owned by E. D. Stirling, Foster & Co. Poughkeepsie, Dutchess county New York, is situated fourteen miles east of that village, and the north part of the town of Beekman, is 9 feet across the bosh by 36 feet high, charges 250 lbs of anthracite * to 10 bushels of charcoal and made in thirty-seven weeks of 1855 1,685 tons of iron out of brown hematite ore, from its own banks in Unionvale town two miles north. The works were damaged by the freshet of August, 1856. The foundry stands ten miles from Poughkeepsie.

36. Fishkill Charcoal Furnace, owned by Isaac White of Hopewell Dutchess county New York, is situated in the village of Hopewell, fifteen miles from Poughkeepsie, and six miles east of Fishkill. It formerly used some anthracite.* It made in 1857 304 tons.

36.5. Haverstraw Furnace on the west side of Tappen Zee was rebuilt but never blown.

36.6. Orange Furnace on Cedar pond near the Orange county southwest line was abandoned more than forty years ago.

37. Greenwood Hot-blast Charcoal Furnace, No. 1, (No. 2 being Anthracite, see Table A. No. 17 page 5) owned by Robert P. and Peter P. Parrott, and managed by the latter, is situated half a mile east of the New York and Erie railroad station Greenwood, Orange county New York, was built in

* Not included in the Anthracite Table A.

1811, and enlarged in 1825, to 11 feet in the bosh by 42 feet high, and made in 1856 1,500 tons of metal out of the same magnetic ores described in the account of Greenwood Furnace, No. 2.

38. Southfield Hot-blast Charcoal Furnace, owned by Peter Townsend & Co. No. 42 Pine street New York, is situated half a mile west of the New York and Erie railway station Southfield, Orange county New York, forty-three miles from the city, on the Mombasha Creek, was built about the beginning of the century, rebuilt in 1839 12 by 40 inside, and made in one blast from October 11, 1850, to July 3 1853 with sixty-two days stoppages 6,353½ tons of metal out of magnetic ore from the Sterling Mines, six miles to the southeast.

38.5. **Woodbury Charcoal Furnace** ten miles from Southfield on the turnpike to Newburg eleven miles from Newburg is in ruins.

38.6. **Old Sterling Charcoal Furnace** built by the Townsends, 5 × 25, and standing two miles north of Sterling No. 2, the furnace next to be described, has been an abandoned ruin for half a century past.

39. Sterling Hot-blast Charcoal Furnace, No. 2, (No. 1 is anthracite) owned by the same parties as the last, is situated in Warwick township Orange county New York, four miles west of the New York and Erie railway station Sloatsburg and half a mile from the New Jersey State line, was built in 1847, is 13 feet wide across the bosh by 48 feet high inside, and made in forty-eight weeks of 1857 2,520 tons of metal out of magnetic ores from the Lower California bank 1¾ miles north; the Upper California bank 2 miles north; Summit bank 2¼ miles north; the great Sterling vein 2⅓ miles north; the 14 foot vein 4 miles north, and close by the Oregon bank, 8 feet thick; the Crossway bank 4¼ miles north; the Mountain mine 4½ miles north; Long mine 4¾ miles north; six or seven other small veins are near the furnace.

39.5. **Ringwood Furnace** has been out of blast for over thirty years and is in ruins.

39.6. Renton's Patent Semi-Bituminous Coal Furnace No 1 owned by James Quimby of Newark, managed by Joseph Marteen, and situated on the Passaic river one mile north of the centre of Newark, was built in 1854 with a chamber 11×13 feet inside, containing eight vertical tubes ten inches by eigh-

teen, holding each a ton of finely powdered magnetic ore mixed with 250 lbs. of ground Cumberland coal. It produced a little iron in 1854 and none afterwards.

39.7. Renton's Patent Semi-Bituminous Coal Furnace No. 2 was built in 1857 and began to work in April. Its chamber is 16 feet square and contains forty-eight tubes six inches by eighteen. A hammer is necessary in the operation and makes these furnaces properly forges. A description of the process may be found in the Scientific American of Feb. 11, 1854 and in the American Iron Manufacturer's Journal, Supplement, Jan. 1853.

40. Freedom Hot-blast Charcoal Furnace, owned by Peter M. Ryerson of Pompton, Passaic county New Jersey, is situated at Wanauque on Ringwood river five miles north of Pompton, 5 miles south of Ringwood, 13 miles northwest of Paterson, 29 miles northwest of New York, was built in 1838, is 12 by 44 feet wide and high inside, and made in 1854 about 2,000 tons of iron for the Pompton Rolling Mill, out of magnetic ore from Ironhill one and a half miles west and from Ringwood. Out of blast since the summer of 1855. Last leased and run by Wallace and Concklin.

41. Pompton Hot-blast Charcoal Furnace, owned by Wm. C. Vreeland and others of Bergen Point, Hudson county New Jersey, is situated on the Ramapo river and Paterson and Hamburg turnpike at Pompton, Passaic county New Jersey, twenty-four miles northwest from New York city, was built in 1837, and formerly owned by the Ryerson Iron Company; is 12 by 44 feet wide and high inside, and said by its owner to be the oldest three tuyère furnace in the United States. Its product was the same as that of the Furnace last described, and it went out of blast a few months earlier.

41.5. Old Charlottenburg Charcoal Furnace, standing in a bend of the Pequannock river, seven miles above Bloomingdale, and eleven miles north of Rockaway in Morris county New Jersey, occupied the present site of the Charlottenburg Forge (Table F. No. 31) and was abandoned in 1772; a piece of pig metal from it is preserved stamped with the date of 1770.

41.6. Hope Furnace, four miles northwest of Rockaway, Morris county New Jersey, stopped thirty years ago.

42. Wawayanda Warm-blast Charcoal Furnace, owned by Oliver Ames and Son of North Easton Massachusetts, and managed by J. A. Brown, is situated at the outlet of the Wawayanda Lake in Sussex county New Jersey, fifteen miles west of Stirling (see No. 39 above), was built in 1845, is 11 by 42 feet wide and high inside and made in forty weeks of 1854 1,852 tons of car-wheel metal from magnetic ore from its mines two and a half miles northeast.

42.5. Hamburg Furnace, Sussex county New Jersey, has been out of blast for more than thirty years and is a ruin.

43. Franklin Hot-blast Charcoal Furnace, owned by the New Jersey Franklinite company, Jas. H. Holdane president No. 84 Washington street New York, is situated in Franklin Village, eighteen miles north of Dover and twelve from the Newton railroad station. It is one of the oldest and perhaps the most widely celebrated of all the American furnaces by reason of the peculiarity of its ores and consequently of its iron. Built in 1770 it was last repaired in 1854 with an 8 foot bosh and 22 feet high, its tunnel head of 8 feet width contracted downwards to make (with anthracite*) iron and zinc together of which last metal its ores contain as much as 20 per cent. The experiment did not succeed and the stack is to be again changed and steam applied in lieu of water power. Previous to 1852 the furnace ran with charcoal upon brown hematite and magnetic ores combined, the former coming from Edsall's mine near Hamburg, three miles north, among the Lower Silurian Limestones, the latter from mines close by and from Ogden's mine five miles southeast. The franklinite or zinc iron ore is mined three hundred yards north of the stack.

43.5. Clinton Charcoal Furnace owned by the Pequannock company, and situated four miles north-northwest of Charlottenburg, nearly two miles from the Pequannock river, on a run from Buck and Cedar ponds, has been idle for ten years, the forge attached to it stopping in 1853.

44. Oxford Steam Hot-blast Charcoal and Anthracite Furnace, owned by Chas. Scranton & Co., managed by Chas. Scranton, situated at Oxford, Warren county New Jersey, on a branch of Pequest River, near where the Warren railroad crosses

* Not noticed in Table A.


Map
FURNACES, FORGES & ROLLING-MILLS
EASTERN PENNSYLVANIA,
SOUTHERN N.YORK.
NEW JERSEY.
EASTERN VIRGINIA,
DELAWARE
and
MARYLAND.
Forges
Canals
TOWANDA
SCRANTON
WILLIAMSPORT
DANVILLE
BELLEFONTE
LEWISTOWN
ALTOONA
FRANKSTOWN
HUNTINGDON
EASTON
BOONTON
MORRISTOWN
READING
HARRISBURG
CARLISLE
LANCASTER
YORK
BEDFORD
CHAMBERSBURG
WILMINGTON
BALTIMORE
HARPERSFERRY
WINCHESTER
VIRGINIA
AMHERST
BUCKINGHAM
CAMPBELL

it five miles southeast of Belvidere. It is said to be the oldest remaining furnace in the Union, ancient castings being found in chimney backs a century old, and pigs are found stamped 1755 (45?) It is in complete repair and runs two-thirds of the year on charcoal and one-third on anthracite, sometimes using one-sixth anthracite.* It is 8 feet wide across the bosh by 38 feet high and made in 1857 906 tons of car-wheel iron nearly all of it manufactured into wheels upon the spot. Formerly the iron was rafted in Durham boats from Foul Rift down the Delaware to Philadelphia. Its ores are black magnetic from banks half a mile distant, worked since 1743.

45. **Lehigh Cold-blast Furnace,** owned by Balliot's heirs, Levan & Balliot lessees, N. Whitehall Lehigh county Pennsylvania, A. Balliot manager, is situated on Trout creek behind the Kittatinny mountain, four miles southwest of the Lehigh Water Gap, was built in 1826, is 7½ by 31 feet wide and high, inside, and made in twenty-six weeks of 1857 554¾ tons of iron out of brown hematite ore from across the mountain nine miles off, southeast.

46. **Maria Hot and Cold-blast Charcoal Furnace,** owned by S. Balliot & Co., and managed by S. Balliot of Weissport, Carbon county Pennsylvania, is situated on Big or Poco Creek 2 miles from Weissport and 3 from Parryville Station on the Lehigh Valley railroad. It is supposed to be a very old furnace, rebuilt in 1834 and again in 1845, is 8 feet wide by 30 feet high inside and made in thirty weeks of 1856 1152 tons of hot-blast iron out of brown hematite ore from Whitehall, Lehigh county.

47. **Pennville Hot and Cold-blast Charcoal Furnace,** owned by Stephen Balliot's heirs and managed by John Balliot of North Whitehall Lehigh county Pennsylvania, is situated in Carbon county 4 miles southwest of Lehighton Station on the Lehigh Valley railroad, at the north fort of the Blue Mountain near Dinkie's tavern. It was built in 1837, rebuilt in 1853, is 9 feet wide by 32 feet high inside, and is reported to have made as much as 1600 tons of cold-blast metal in each of the years

* Not noticed in Table A.

1854 and 1855 (since when it has stood idle) out of brown hema tite ore.

48. Hampton Cold-blast Furnace, No. 1, owned by Frederick Sigmund & Co. Hereford P.O. Berks county Pennsylvania, is situated in Lehigh county twelve miles southwest from Allentown, near Sheimersville at the head of the north branch of the Perkiomen creek, Upper Milford township, twenty-five miles east of Reading. It was built in 1809, is 6 feet wide at the top of the bosh and 32 feet high inside, and made in twenty-eight weeks of 1857 722 tons of "first-class carwheel" iron, out of neutral and somewhat magnetic black oxide from Barto's banks in Washington township seven miles off southwest, mixed with brown hematite ore from the neighboring Lower Silurian Limestone land.

49. Mary Ann Cold-blast Charcoal Furnace, owned by Horace Trexler and managed by Dr. E. Trexler, Long Swamp P.O. Berks county Pennsylvania, is situated five miles from Hampton furnace last described, on the northeast borders of Berks county, 18 miles northeast of Reading, in Long Swamp township, at the head of Little Lehigh Creek, 9 miles east-southeast of Kutztown, and 8 miles south-southwest of Trexlertown. It was built in 1797, is 7 feet wide across the bosh by 30 feet high inside, and made in 1856 about 700 tons of metal out of three-fourths brown hematite and one-fourth magnetic ores from beds within a radius of two miles.

50. Oley Cold-blast Charcoal Furnace was formerly owned by Udee, and afterwards by Snyder, stood idle about 12 years and was started again for a short time four years ago by Dr. Herbst, Palm and others and is now owned by Murkells and Levan, and managed by Samuel Murkells, Pricetown, Berks county Pennsylvania, is situated two miles east of Pricetown and eleven and a half miles northeast of Reading. It is still older than the two furnaces last described, having been built in 1770, is 9 by 30 inside, and made in thirty-six weeks of 1857 757½ tons of wheel iron out of brown hematite ore from Deishler's bank eight miles northeast, mixed with magnetic ore from Zinner's bank at Rothruckville, twelve miles north.

51. Sally Ann or Rockland Cold-blast Charcoal Furnace, owned by Jacob V. R. Hunter of Reading and managed by J. N. Hunter, Dreysville P.O. Berks county Pennsylvania, is situated on Sacony creek, five miles south of Kutztown and sixteen miles from Reading, was built in 1791, is 8 feet wide across the top of the bosh and 32 feet high and made in 1856 about 600 tons of iron out of one-fourth brown hematite ore from Trexlertown or the old Moselem bank, and three-fourths "flat ore."

52. Mount Laurel (but formerly Alsace) **Cold-blast Charcoal Furnace,** owned by W. H. Clymer & Co. of Reading, Berks county Pennsylvania, is situated on Mount Laurel creek, 6 miles north-northeast of Reading, $1\frac{1}{4}$ miles east of the State road to Easton. It was built in 1836, is 8 by 30 feet inside, and made in forty-five weeks of 1855 954 and in forty-four weeks of 1856 952 tons of car-wheel iron out of brown hematite ores from the old Moselem bank eight miles west and from Dumm's and Hefner's banks six and ten miles off on the flank of the South Mountain, mixed with a magnetic ore, similar to the Cornwall, from the Wheatfield banks in Spring township thirteen miles southwest and seven from Reading.

53. Maiden Creek Cold-blast Charcoal Furnace, owned by George Merkle of Leonardsville, Berks county Pennsylvania, is situated twenty miles north of Reading on Maiden creek, was built in 1854, is $7\frac{1}{2}$ by 31 feet inside and made in forty-six weeks of 1857 1,024 tons of metal out of brown hematite ores from the Moselem bank seven miles off, the Coxtown bank ten miles and the Trexlertown bank thirteen miles east.

54. Mount Penn Cold-blast Charcoal Furnace, owned by Shalter and Kauffman of Reading, Berks county Pennsylvania, is situated on the west side of the Schuylkill river half a mile off and two miles from Reading, was built in 1827, is 8 by 31 inside, and made in six months of 1856 perhaps 500 tons.

55. Hampton Hot and Cold-blast Charcoal and Anthracite Furnace, No. 2, owned by E. and G. Brooke of

Birdsborough, Berks county Pennsylvania, is situated on Hay creek, two miles south of Birdsborough, was built in 1846, 8 feet wide by 28 feet high inside, and made in 1854 1,760 tons of metal. It* makes some anthracite iron every year. Its ores are magnetic from Jones' and the Warwick banks about six miles south.

56. Joanna Cold-blast Charcoal Furnace, owned by Wm. Darling, Levi B. Smith, B. H. Smith and Wm. D. Smith, is situated on Hay creek, nine miles southwest of Birdsborough and twelve miles south-southeast of Reading, was built in 1794, is 7½ feet across the bosh by 28 feet high inside, and made in fifty weeks of 1855 1,162 tons of metal out of magnetic ore from Jones' bank two and a half miles off and an equal distance from Morgantown, and from the Warwick bank near St. Mary's seven miles off.

57. Hopewell Cold-blast Charcoal Furnace, owned by Clingan & Buckley, and managed by Dr. Clingan, Hopewell Furnace P.O. Berks county Pennsylvania, is situated in the southeast corner of Berks county on French creek, 40 miles above Philadelphia and 14 below Reading, five miles south of Douglassville Station on the Reading railroad, and is just a century old, having been built in 1759, is 6½ by 35 feet inside, and made in forty-three weeks of 1856 796 tons of forge iron out of magnetic ore from the Chester county mines south of the furnace mixed with a small quantity of brown hematite.

58. Warwick Cold-blast Charcoal Furnace, owned by David Potts Jun. of Warwick Furnace, Chester county Pennsylvania, is situated in Warwick township on the south branch of French creek, 13 miles west of Phœnixville, 3 miles west-southwest of Coventry village, ten miles southwest of Pottstown, is still older than the last, having been built in 1736 and is believed by its owner to have been in operation for a longer or shorter period of every year since that time. It is 7½ feet wide across the top of the bosh and 30 feet high inside and made in thirty-nine weeks of 1857 759 tons of boiler plate metal (such as it has

* Not noticed in Table A.

exclusively been making for sixteen years past) out of magnetic ore from the Warwick, the St. Mary's, Jones's six miles off north of west and the Chester county mines two and a half miles off.

58.5. Mount Eden, Rock or Greenwood Furnace eight miles north of Whiterock, six miles south of Strasburg, was abandoned ten years ago and is in ruins. See Greenwood Forge Table F. No. 107.

58.6. Isabella Furnace was converted into a Forge in 1853. See Table F. No. 103.

59. Elizabeth Steam Hot-blast Charcoal Furnace, owned by George Dawson Coleman of Lebanon, was abandoned in 1856 for want of wood. It is a very old furnace built in 1756 at the southern base of the South Mountain in the northern part of Lancaster county Pennsylvania, near Litiz, fourteen miles north of Lancaster. It is 9 by 28 inside and made in fifty weeks of 1855 1,424 tons of metal out of Cornwall grey magnetic ore.

60. Mount Hope Cold-blast Furnace, owned by Ed. B. & A. Bates Grubb, and managed by Wm. Boyd of Mount Hope P.O. Lancaster county Pennsylvania, is situated on the Big Chiquisalunga creek between Lancaster and Lebanon six miles south of the latter. Built in 1785, it was rebuilt of sandstone several times, last in 1824 or '25. It is 7 by 27 inside, and makes perhaps 1,000 tons of grey iron per annum for the neighboring forges out of grey magnetic ore from the Cornwall mine three miles off to the north.

60.5. Mount Vernon Hot-blast Charcoal Furnace No. 1 owned by E. B. & A. B. Grubb, and situated on the Conewago river and on the Lancaster and Harrisburg railroad, fifteen miles from Lancaster, was built in 1800 and stopped in 1852. It was 8 × 26 and used both Cornwall grey magnetic and Columbia brown hematite ores to make foundry iron for Baltimore and Philadelphia, 35 tons a week.

60.6. Mount Vernon Furnace No. 2 stands near the last, has the same owners and was built in 1835, then turned into a forge and back into a furnace again. See Table F. No. 111.6.

61. Colebrook Cold-blast Charcoal Furnace, owned by William Coleman, stands on the Conewago creek in Lebanon county Pennsylvania, and on the road from Lancaster to Annville, ten miles south southwest from Lebanon. It is very old, having been built in 1745, is 9 feet wide inside across the bosh and 30 high, and made in forty-three weeks of 1856 1,036 tons

of wheel and forge iron, out of the grey magnetic ore of the Cornwall mine seven miles off to the east.

62. Cornwall Steam Cold-blast Charcoal Furnace, owned by Robt. W. Coleman, is six miles south of Lebanon in Lebanon county Pennsylvania, of the same age and present size as the last, uses the same ore and made in forty-eight weeks of 1856 1,020 tons of similar metal.

63. Manada Hot-blast Charcoal Furnace, owned by E. B. Grubb of Burlington New Jersey & C. B. Grubb of Lancaster, and managed by J. Care, West Hanover P.O. Dauphin county Pennsylvania, stands on Manada Creek in West Hanover township, Dauphin county, one mile south of Manada Gap in the Blue Mountains, and 6 miles from the Union Canal, at a point 15 miles below Lebanon, and thirteen miles northeast of Harrisburg. Built in 1837 it was reduced in size in 1839 to 8 feet across the bosh by 33½ feet high inside, and made in 1855 1,598 tons of metal out of brown hematite (cold-short) from Chestnut-hill near Columbia, mixed with grey magnetic ore from Cornwall near Lebanon.

64. Georgiana Hot-blast Charcoal Furnace, owned and managed by Dr. Lewis Heck of Dauphin, stands nearly on the site of the old Emmeline Furnace (built about 1835) on the Susquehanna river and canal and railroad a mile and a half above Dauphin, Dauphin county Pennsylvania. It was built in 1855, 9 by 31, made 42 tons a week for four months and has been idle ever since. It used magnetic ore from Dillsburg in York county, eight miles south-southeast of Mechanicsburg.

64.5. Victoria Charcoal Furnace, on Clark's creek eight miles above Georgianna Furnace last described has stood idle a dozen years and is in ruins.

65. Rock Hot-blast Charcoal Furnace, in Lancaster county twelve miles southwest of Penningtonville was built in 1832, 8 by 29, made perhaps a thousand tons in 1854, was stripped of its machinery and is abandoned.

66. Conowingo Steam and Water Cold-blast Charcoal Furnace, owned and managed by J. M. Hopkins, stands on the creek nearly two miles southeast of Buck P.O. Lancaster county Pennsylvania and sixteen miles south-southeast of the city. It

was built about fifty years ago, is 7½ feet wide by 30 high inside and has made in eight months of each year perhaps 800 tons of iron out of brown hematite ore from banks five miles off to the northeast.

67. York Cold-blast Charcoal Furnace, owned by J. Bair & Co., leased by Hopkins and Bair, and managed by John Bair, stands one mile below Colemanville, York county Pennsylvania (or Shunks Ferry over the Susquehanna river), was built in 1830, is 8 by 32 inside and made in 1855 perhaps 1,000 tons of car-wheel iron out of Conowingo brown hematite ore from Drum's township.

68. Margaretta Steam and Water Hot-blast Charcoal Furnace, owned by Himes and Hahn and leased and managed by Thomas Himes, stands on Cabin Branch creek in Canadocholey Valley, Lower Windsor township, 4 miles south of Northern Central Railroad between York and Wrightsville, 2 miles west of Tidewater Canal, and 4½ miles south of Wrightsville, York county Pennsylvania. Built in 1825 and rebuilt in 1837 it is 7½ feet wide across the bosh by 33 feet high, and made in thirty-eight weeks of 1854 about 800 tons of metal out of brown hematite ore from a large bank near by, and another two miles west. It has made no iron since 1854.

69. Chestnut Grove Steam and Water Cold-blast Charcoal Furnace, owned by Charles Wharton jun. stands half way between Carlisle and Chambersburg in Adams county Pennsylvania, half a mile off the main road, was built in 1830, is 8½ feet by 33 inside, and made in thirty-one weeks of 1856 650 tons of car-wheel iron out of magnetic ore from a mine one mile east, mixed with one-fourth brown hematite from a bank five miles north.

70. Carlisle Cold-blast Charcoal Furnace, owned and managed by Peter Ege, Boiling Spring P.O. Cumberland county Pennsylvania, stands at the entrance of the Boiling Spring water into Yellow Breeches creek five miles southeast of Carlisle, was built in 1815, and afterwards enlarged to 8½ feet in the bosh and 27 feet high, and made in six months of 1856 about 300 tons of forge iron out of brown hematite ore from a bank two and a half miles south, mixed with magnetic ore from a mine six miles east-southeast.

71. Holly Hot-blast Charcoal Furnace in Holly Gap on Mountain Creek six miles south of Carlisle was built in 1795 and in 1855 torn down to give place to a paper mill. It was 8 by 33 and had rich cold short ore banks, one quarter of a mile off, another six miles southwest.

72. Pine Grove Hot-blast Charcoal Furnace, owned by Wm. M. Watts, stands with Laurel Forge on Mountain creek main branch of Yellow Breeches creek, 14 miles southwest of Carlisle, and 16 miles due north of Gettysburg, in Cumberland county Pennsylvania. It is very old (1770), is 8½ feet wide across the bosh by 33 feet high, and made in twenty-three weeks of 1857 668 tons of forge metal, out of brown hematite ore from banks half a mile distant.

73. Big Pond Steam Cold-blast Charcoal Furnace, owned by Schoch, Sons & Co. and managed by Isaac S. Matthew, stands on Big Pond stream in Big Pond Gap, two miles south of Walnut Bottom road, six miles east of Shippensburg in Cumberland county Pennsylvania, was built in 1836, is 8½ by 33 inside, and made in twenty-two weeks of 1857 462½ tons of iron out of brown hematite ore from mines one mile west.

74. Cumberland Cold-blast Charcoal Furnace, ten miles southwest of Carlisle, situated on Yellow Breeches creek, north side of South Mountain, 11 miles northeast of Shippensburg 7 miles west of Mount Holly, 8 miles east of Big Pond. Has been entirely abandoned from scarcity of charcoal, and the property divided and sold; the stack is being demolished to make room for a paper mill. It was built in 1794 and used brown hematite ores from the Peach Orchard bed 3 miles west, McCulloch's and Goodpart's beds 2 miles northwest, Lee bank 5 miles north; Dillstown 13 miles due east.

74.5. Southampton Furnaces No. 1 and 2 in Southampton township, Franklin county Pennsylvania, three miles south of Shippensburg, have made no iron since 1851 and were torn down in 1854. A large forge near them was torn down in 1849.

74.6. Mary Ann Furnace, in the same town and four miles distant from Shippensburg, last owned and worked by Charles Wharton junior, was abandoned in 1851.—Mary and Augusta are mentioned as names of furnaces in this district, out of blast.

75. Caledonia Hot-blast Charcoal Furnace, owned by Thaddeus Stephens' heirs and managed by Henry Sloat, stands ten miles east of Chambersburg on the Chambersburg and Baltimore pike in the South Mountain, at the crossing of Conecocheague creek, was built in 1837, is 8 feet wide across the top of the bosh and 33 feet high inside, and made in 1855 perhaps 800 tons of metal out of brown hematite ore from banks four miles west.

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76. Mont Alto Hot-blast Charcoal Furnace, owned by Holker Hughes, Mont Alto P.O. Franklin county Pennsylvania, situated nine miles southeast of Chambersburg, 1 mile from Funkstown, was built in 1807 and never rebuilt, is $9\frac{1}{2}$ by 30 feet inside and makes annually about 900 tons of metal out of brown hematite ore dug within 300 yards southeast of the furnace, four banks in a quarter of a mile.

77. Carrick Cold-blast Charcoal Furnace, owned by J. R. Brewster, leased by S. Walker and managed by Wm. Noonan, Fannetsburg P.O. Franklin county Pennsylvania, stands on the west bank of the Conecocheague, 4 miles south-southwest of Fannetsburg, 8 miles north of Loudon. It was built in 1828, is 7 feet wide by 30 high inside and made in 1855 200 tons of iron out of Upper Silurian red fossil ore found $2\frac{1}{2}$ miles southwest, cropping all along the west base of the mountain (in Formation V. Clinton Group), from about Fannetsburg down to Louden, for 15 miles; another opening half a mile west of furnace in not quite so good ore; another $2\frac{1}{2}$ miles north, the best of all.

78. Valley Cold-blast Charcoal Furnace, owned by J. Beaver and leased and managed by J. Polsgrove, Loudon P.O. Franklin county Pennsylvania, stands two miles north of Loudon on West Conecocheague Creek, close by the forge, but was built long after it, say 35 years ago. It is only $5\frac{1}{2}$ feet wide across the bosh and 28 feet high, shares its blast with the forge and made in 1856 perhaps 500 tons of forge metal out of brown hematite ore found about four miles north. It has been out of blast three years.

78.5. Mount Pleasant Furnace and Forge four miles south of Loudon were both destroyed together in 1843.

78.6. Loudon Furnace and Forge in the edge of Loudon were destroyed in 1840.

79. Franklin Cold-blast Charcoal Furnace, owned by B. Phreaner's heirs, St. Thomas P.O Franklin county Pennsylvania, Dr. Samuel Behm (Lebanon) and Chas. Mulley (Pinegrove) administrators. Situated 3 miles northwest of Campbellstown (which is $7\frac{1}{2}$ miles from Chambersburg, towards Loudon), and 4 miles from the brick tavern ($3\frac{1}{2}$ miles east of Loudon), it is $7\frac{1}{2}$ by 30 feet inside and stopped in 1853 and has made nothing

since. It is in good order however and has brown hematite ore banks (Beaver's) near Loudon, and the old Hensam bank half a mile west and a third one and a half mile north.

80. Warren Steam Hot-blast Charcoal Furnace, owned by W. Bower's heirs, R. Lewis and Co. Lessees, Sylvan P.O. Franklin county Pennsylvania, is situated one and a half mile north of the State line in Warren township, on little Cove Creek, 6 miles from Millstone Point on the Chesapeake and Ohio Canal, in a cove of the North Mountain opening southwards and filled with upper silurian rocks, a cove lined with Formation V. with its fossil ore. It was built about 1833, is 7½ by 28 feet inside, and made in 25 weeks of 1856 535½ tons of rolling-mill iron out of red fossil ore from a mine one mile west, mixed with some brown hematite from Baltimore and the Point of Rocks.

81. Principio Hot-blast Charcoal Furnace, owned by Joseph and Geo. P. Whitaker of Philadelphia and managed by G. P. Whitaker, is situated on the Baltimore railroad three miles east of the Susquehanna, is 8½ feet wide across the bosh by 32 feet high inside, and made in thirty-seven weeks of 1856 about 800 tons of metal out of ores of all kinds from Baltimore and Harford counties and from New Castle, Delaware.

82. Lagrange Hot-blast Charcoal Furnace, owned by Rogers and Sons of Pittsburg, Jarrettsville P.O. Harford county Maryland, is situated at the Falls of Deer Creek, thirty miles north of Baltimore, six miles from the Pennsylvania line, three miles northeast of Coopstown, eight miles from Harford county line, nine miles north of Belair, twelve west of Darlington, and ten south-southwest of Peachbottom in Pennsylvania on the Susquehanna. It was built in 1836; is 6 by 35 feet inside, and is reported to make in six months of each year about 780 tons out of brown hematite ore from a bank six miles a little south of west and seven-eighths of a mile south of the State line. It has a small bed in Westminster township Carroll county Maryland.

83. Sarah Steam and Water Hot-blast Charcoal Furnace, owned by P. A. & S. Small of York in Pennsylvania and managed by A. P. McCombs, is situated 24 miles north of Balti-

more, near the head of Winter's Run on the road leading from Jarrettsville to the Old Baltimore Road, ten miles northwest of Belair, twenty miles south of McCall's Ferry and five miles southwest of the Rocks of Deer Creek. It was built in 1841, rebuilt in 1851, is 6½ by 31 feet inside, and made in thirty-five weeks of 1856 971 tons of metal out of hematite ore from banks two miles to the south of it.

84. **Harford Steam and Water Cold-blast Charcoal Furnace,** owned by Richard Green of Cockeyville, and managed by William Carmell, is situated four miles west of Perrymansville, on the head waters of Bush River, near the railroad bridge, and twenty-five miles northeast of Baltimore; was built in 1828, rebuilt in 1845; is 7½ feet wide by 33 high inside, and made in forty-six weeks of 1857 1,421 tons of car-wheel metal out of carbonite ores from the shores of Bush River, Gunpowder River and Caba River, mixed with hematite ore from banks alongside of the Northern Central railroad.

85. **Locust Grove Steam and Water Hot-blast Charcoal Furnace,** owned by Robert Howard of Baltimore and managed by George R. Burroughs, Stemmer's Run P.O. Baltimore county Maryland, is situated close by the Stemmer's Run Station on the Baltimore railroad. It was built in 1844, is 7½ feet wide by 30 feet high inside, and made in thirty weeks of 1857 1,277 tons of metal out of hematite ore.

86. **Gunpowder Hot-blast Charcoal Furnace,** owned by Robert Howard of Baltimore and managed by John S. Hawes of Little Gunpowder P.O. Baltimore county Maryland, is situated on the Philadelphia turnpike fourteen miles east of Baltimore at the Great Falls of Gunpowder six miles from Locust Grove Furnace and half a mile north of Patterson's nail mill. It was built in 1846, is about 8 feet wide across the top of the bosh by 31 feet high inside, and made in thirty weeks of 1856 perhaps 1,100 tons of foundry and forge metal out of hematite ores.

87. **Chesapeake Steam Hot-blast Charcoal Furnace,** No. 1, owned by S. S. Lee & Company and leased by Hugh Jenkins, stands just outside the limits of the City of Baltimore in Canton on the east side of the harbor. No. 1 built in 1845 is 8 feet wide by 32 feet high inside and is reported to

have made in fifty weeks of each year about 2,200 tons of chiefly forge metal out of argillaceous hematite ores from the neighborhood.

88. Chesapeake Steam Hot-blast Charcoal Furnace No. 2 was built in 1853 and is a duplicate of No. 1, making out of the same ores the same quantity of iron. The markets of these furnaces are in Massachusetts, at Philadelphia, Richmond and Wheeling on the Ohio River.

89. Cedar Point Steam Hot-blast Charcoal Furnace A, formerly known as the Munsen Iron Works, is owned by Peter Mowel of Baltimore and leased by Hugh Jenkins. It stands on Boston street Canton on the east side of Baltimore harbor beside the Philadelphia railroad just above the station two miles from the centre of the city and a mile north of the Chesapeake furnaces last described. Built in 1843, 8 feet by 31 inside, it made in fifty weeks of 1856 about 2,700 tons of car-wheel iron for Philadelphia, Norristown and Fall River in Massachusetts, out of brown hematite ores.

90. Cedar Point Steam Hot-blast Charcoal Furnace A, standing alongside of B, was built two years later, in 1845, of the same size, and made in the same time 2,838 tons of similar metal from the same ores.

91. Maryland Steam Hot-blast Charcoal Furnace No. 1, owned by H. W. Ellicott and Brother, Box 55 Baltimore city P.O. stands on the south side of the Baltimore basin, was built in 1840, is 9 feet wide by 30 high inside, and made in forty-eight weeks of 1854 about 2,000 tons of forge metal out of argillaceous hematite ores from the Covington bank four miles south of Baltimore, Williams's bank at Annapolis junction and Miller's bank fifteen miles southwest on the Washington railroad; since when it has made nothing.

92. Maryland Steam Hot-blast Charcoal Furnace No. 2 stands beside No. 1 but is much younger not being built till 1853. Its size however is the same and it made in twenty-nine weeks of 1856 1,058 tons of forge metal. The market is in Baltimore.

93. Laurel Steam Hot-blast Charcoal Furnace, owned by D. M. Reese, Laurel Furnace, Baltimore Maryland, is situated

side by side with South Baltimore Furnace, No. 118 of Table A, on the south Baltimore wharves, one and a half miles from the centre of the city. It was built in 1846, is 9 feet wide by 31 feet high inside, and made in forty-four weeks of 1855 2,162 tons of metal out of the ores described under No. 118 Anthracite Table A.

94. Cecelia Steam Hot-blast Charcoal Furnace, owned and managed by John Ahern, is situated on Patapsco River on tide, southeast from Baltimore and just beyond the city limits, was built in 1854, is 9 feet across the bosh by 33 feet high inside, and made in forty-three weeks of 1857 1,881½ tons of metal out of the Baltimore bone and chocolate, chiefly carbonate, ores from banks about four miles northeast of Baltimore along the Philadelphia turnpike.

95.5. Patapsco Furnace, owned by W. H. Ellicott, situated one mile east of Maryland Furnace No. 91 at Locust Point made no iron after 1849 and was torn down in 1853.

95.6. Curtis's Creek Furnace, owned by Wilkens Glenn of Baltimore and situated in Patapsco county eight miles southeast of Baltimore, is very old and in a ruinous condition, the machinery removed or scattered round. It stopped finally in 1851.

95. Patuxent Steam Hot-Blast Charcoal Furnaces, No. 1 and No. 2, owned formerly by Lemmon and Glenn, and situated on little Patuxent River three miles south of Annapolis junction, were almost the same size with the Maryland Furnaces; were dismantled and destroyed in June 1856 for want of wood and ore. Never more than one furnace was in blast at once. These furnaces occupied the site of a much older puddling furnace long since destroyed. Capacity about 50 tons a week.

97. Elk Ridge Steam and Water Hot-blast Charcoal Furnace, owned by the Great Falls Iron Company and managed by Jos. D. Pettit, Elk Ridge Landing P.O. Ann Arundel county Maryland, is situated on the site of the old Howard Furnace built in 1826, at Elk Ridge Landing on the Washington railroad. It was built in 1854, is 9½ feet wide by 32 feet high inside, and made in thirty weeks of 1857 1,564½ tons of chiefly forge iron for Baltimore, Wheeling and the Avalon Iron Works.

97.5 Savage Furnaces, Nos. 1 and 2, owned by the Savage Manufacturing Company and standing quite in ruins near the Washington railroad twenty miles from Baltimore have been out of blast for twenty years. There is a cupola furnace here, never used and now dilapidated.

98. Muirkirk Steam Hot-blast Charcoal Furnace, owned by Wm. E. Coffin & Co. Boston, and managed by George Cary, is situated in Prince George's county Maryland, twenty-five miles from Baltimore southwest along the railroad to Washington; was built about 1842; is 8 feet wide by 28 feet high inside, and is reported to have made in 1856 2,200 tons of metal out of the same kind of ore as that at the Chesapeake Furnaces.

99. Elba Steam and Water Charcoal Furnace, owned by James W. Tyson of Sykesville, Carroll county Maryland, is situated on the Baltimore and Ohio railroad, at Sykesville, thirty-one miles west of Baltimore; was built about 1847, is 8½ feet wide by 30 feet high inside, and made in thirty-three weeks of 1857 965 tons of car-wheel metal out of hematite ore from banks two miles north of Mount Airy on the Baltimore and Ohio railroad, forty miles west from Baltimore, in Frederick county, mixed with magnetic ore from mines two miles north of the furnace and one and a half miles northeast from Sykesville in Carroll county and with carbonates got two miles from the Relay House in Howard county on the Washington railroad.

100. Catoctin Hot-blast Charcoal Furnace, No. 1, owned by Jacob M. Kunkle of Frederick county Maryland, and R. Fitzhugh, is situated twelve miles north-northeast from Frederick and three miles from Mechanicstown; was built in 1774, rebuilt in 1787, and again rebuilt about 1831, is 9 feet wide by 33 feet high inside, and annually makes in about thirty weeks perhaps 1,000 tons of forge and foundry metal out of ores from Fitzhugh and Kunkle's bank one mile north of the furnace.

101. Catoctin Steam Cold-blast Charcoal Furnace, No. 2 was built in 1857 alongside of No. 1 of the same size to run upon the same ores.

102. Antietam Hot-blast Coke and Charcoal Furnace, owned by John Herine of Bloomsborough, Washington county, and the heirs of Wm. B. Clark, has been leased by Herine, Yeakle & Co. Sharpsburg, Maryland, and managed by Jacob Hewitt. It is situated at the junction of Antietam Creek with the Potomac River, seven miles above Harper's Ferry by the country road and nine miles by the canal, was built in 1845, is 15 feet across the bosh by 50 feet high inside, and made in twenty

weeks of 1857 1,465 tons of hard metal for Wheeling and Boston. Old Antietam furnace was built on this spot as much as a century ago.

103. Greenspring Hot-blast Charcoal Furnace, owned by J. D. Roman & Co. and managed by B. F. Roman, Greenspring P.O. Washington county Maryland, is situated three miles from Clearspring, six miles from Hedgesville and one mile from McCoy's Ferry and the canal, was built in 1848, is 8 by 35 inside, and made in thirty-two weeks of 1856 677 tons of forge and foundry metal out of hematite ore from banks three miles to the north and also one mile to the south of it.

104. Schickshinny Hot and Cold-blast Charcoal Furnace, owned and managed by B. D. Koons of Nanticoke, Luzerne county Pennsylvania, is situated in the gap of Schickshinny mountain seventeen miles below Wilkesbarre where the creek enters the elbow of the Susquehanna from the north, and on the west side of the creek. It was built in 1846, is 9 feet wide across the bosh by 33 feet high inside, and made in about nine weeks of 1856 300 tons of metal out of two-thirds hematite ore from near Bloomsburg in Columbia county twenty-two miles down the river, mixed with one-third bog ore from Newport township, Luzerne county, four miles east of it.

105. Catawisssa Hot-blast Charcoal Furnace, owned by G. and R. Shuman, Maineville, Columbia county, Pennsylvania, is situated on Catawissa Creek five miles east of the village. It was built in 1815, is 7½ by 28 inside and made about 1,000 tons of metal per annum in 1855 and '56, was sold and went out of blast Jan. 8. 1857, and is probably abandoned.

106. Penn Hot-blast Charcoal Furnace, owned by J. Penn Fincher, stands on Catawissa Creek, half mile east of the village and about one hundred yards from the Catawissa railroad in Columbia county Pennsylvania. It was built in 1845, is 7 feet wide by 30 high inside, and made in twenty-four weeks in 1856 790 tons of forge metal out of the fossil ore of Montour's ridge across the river to the north.

107. Esther Hot-blast Charcoal Furnace, owned by S. B. Diemer of Catawissa, Columbia county Pennsylvania, stands about three and a half miles south of Catawissa, on Big Roaring

creek waters, where the Catawissa and Bear Gap road crosses; was built in 1836, is 7½ feet wide across the bosh by 28 feet high and made in thirty-six weeks of 1855 918 tons of metal out of Upper Silurian fossil ore from the Hemlock mines near Bloomsburg, seven miles north, at the foot of Montour's ridge.

107.5. Briar Creek Furnace, owned by C. Kalbfus has not been in blast since 1849.

108. Paxinas Hot-blast Charcoal Furnace, owned by Taggart, Firman & Barton, Paxinas P.O. Northumberland county Pennsylvania, stands on the right bank of the Shamokin Creek five miles north of Shamokin half a mile below and opposite to Reed's Station on the Shamokin and Sunbury railroad. It was built in 1847, is 7½ by 30 feet inside, and made in eighteen weeks of 1855 350 tons of metal out of fossil ore from Dry Valley, Union county, since when it has stood idle and is not likely to be used again.

109. Forest Hot-blast Charcoal Furnace, owned by Kaufman and Reber in White Deer township Union county Pennsylvania, four miles west of Watsontown Station on the Sunbury and Erie railroad, and were Sugar Valley turnpike crosses White Deer creek, was built in 1846, is 9 feet wide inside by 35 feet high and made in all of 1856 1,142 tons of metal.

110. Berlin Cold-blast Charcoal Furnace, owned by Clement and Charles Brooke and managed by J. Church, four miles south of Hartleton Union county Pennsylvania, stands on Penn's creek at Jack's Mountain gap on the Hartleton and Musser Valley road, four miles south of Hartleton, eighteen miles southwest of Lewisburg, twelve miles west of New Berlin. It was built in 1827, is 6 feet wide inside by 32 feet high and made in all of 1855 828 tons of iron.

111. Beaver Steam and Water Hot-blast Charcoal Furnace, owned by Middleswarth, Kerns & Co. and managed by J. C. Wilson, two and a half miles west of Middleburg Snyder county Pennsylvania, stands on two runs descending the north flank of Shade Mountain in Middle Creek valley 12 miles west of Selinsgrove and the Susquehanna Canal, 28 miles east of Lewistown and the Juniata Canal and Pennsylvania Railroad. It was built in 1848, 8½ feet inside across the bosh by 30 feet high inside, and made in thirty-six weeks of 1857

1,030 tons of cold short foundry metal sent to the eastern forges to be mixed for boiler blooms. Ores red (soft and hard) fossil from a line of Upper Silurian (Clinton Group or No. V.) outcrops along the foot of Shade mountain, which is an anticlinal similar to Montour's ridge behind Danville.

112. Heshbon Cold-blast Charcoal Furnace, owned until recently by Wm. McKinney of Newberry Lycoming county Pennsylvania, stands on the Lycoming Creek five miles above its mouth, and opposite McKinney's Bridge Station on the Williamsport and Elmira railroad, was built in 1838, is 6 feet across the bosh by 25 feet high and makes about 300 tons of iron per annum for the adjoining forge and rolling mill, out of brown hematite ore brought from McKinney's banks in Nittany valley Centre county beyond the Bald Eagle mountain to the south.

113. Washington Cold-blast Charcoal Furnace, owned by C. and J. Fallon, leased by Jas. Irvin and managed by Dr. Wm. Irwin, stands in Nittany Valley, on Fishing Creek waters, 8 miles from the canal at Flemington, and 11 miles from Lockhaven by turnpike. It was built in 1811, is 7½ feet across the bosh by 30 high, and made in 1856 about 1,200 tons of metal out of brown hematite pipe ore from two banks within three miles northwest of it.

114. Howard Cold-blast Charcoal Furnace, owned by John Irwin Jr. & Co. situated east of the village, on Bald Eagle Creek and Canal, fourteen miles from Lockhaven intersection, ten miles northeast of Bellefonte, on the north side of Lick Run Gap through Muncy or Bald Eagle Mountain, was built in 1830, is 8 feet across the bosh by 32 feet high, and made in thirty-nine weeks of 1857 1,307½ tons of metal out of brown hematite pipe ore from banks in Nittany Valley three to five miles distant southeast.

115. Hecla Hot-blast Charcoal Furnace, owned by Gregg & Irwin, and managed by J. Irwin Gregg, standing in Logan Gap of Nittany Mountain seven miles southeast of Bellefonte, and eight from the canal, was built in 1826, is 8 feet across the bosh by 33 feet high, and made in thirty-five weeks of 1856 1,030 tons of forge metal out of brown hematite pipe ore

from banks scattered over the central ridge of Nittany Valley the top of which is one and a half miles north of the furnaces.

116. Eagle Hot-blast Charcoal Furnace, owned and managed by C. and J. Curtin, Milesburg, Centre county Pennsylvania, and standing on the Bald Eagle Canal one mile northwest of the rolling-mill, and three miles northeast of Milesburg, was built in 1848, 8 feet across the bosh by 30 feet high, and made in forty-one weeks of 1856 1,078 tons of forge metal out of brown hematite pipe ore obtained from the central "barrens" of Nittany Valley, three miles southeast of Bellefonte.

117. Logan Cold-blast Charcoal Furnace, owned by Valentine & Thomas, leased by Valentine, Thomas & Co. and managed by R. B. Valentine, Junior, situated on Logan Branch of Spring Creek in Nittany Valley two miles southeast of Bellefonte and thirty from Lockhaven, was built in 1800, is 7½ feet across the bosh by 30 high, and made in forty-three weeks of 1856 1,715 tons of forge metal out of brown hematite ore from nests in the (Trenton) limestone of Nittany Valley two and a half miles east.

118. Rock Cold-Blast Charcoal Furnace, owned by Wm. F. Reynolds of Bellefonte, Centre county Pennsylvania, situated on Spring Creek, six miles southeast of Bellefonte, was built in 1816 and rebuilt about 1845, 6½ feet across the bosh by 22 feet high, and made, previous to its abandonment about the middle of 1855, at the rate of 700 tons of metal per annum out of brown hematite pipe ore from banks eight miles on the road to, and eleven and a half miles from, Pinegrove, ten miles east in Penn's Valley, nine miles north in Bald Eagle Valley, and others less than a mile distant in Spring Creek Valley. It is in ruins.

119. Centre Cold-blast Charcoal Furnace, owned by Thompson, McCoy & Co. and managed by Moses Thompson, standing nine miles southwest of Bellefonte on Centre Furnace spring Centre county Pennsylvania on the Bellefonte and Spruce Creek road, was built in 1790, is 8 feet across the bosh by 33 feet high, and made in twenty-four weeks of 1856 684 tons of metal out of brown hematite ore three miles northwest and seven miles east, mixed with pipe ore from a bank one mile distant to the north.

120. Juliana Hot-blast Charcoal Furnace, owned by John Adams, leased by James H. Linn & Co. and managed by R. H. McCoy, standing in Bald Eagle valley Centre county Pennsylvania, on Bald Eagle creek and plank road, ten miles

southwest from Milesburg and twenty from Tyrone, was built in 1835, is 8 feet across the bosh by 30 high, and made in twenty-nine weeks of 1856 925 tons of cold-short metal out of brown hematite ore, from Lambenn bank three miles due south on Buffalo Run, and red-short from River Hill bank four and a half miles south in the barrens of Nittany Valley.

121. Martha Steam Cold-blast Charcoal Furnace, owned by Irwin & Thompson, and managed by John J. Thompson, is situated like Juliana furnace last described but sixteen miles from Tyrone, fifteen from Bellefonte, and fifteen southwest of Milesburg. It was built in 1832, is 8 feet across the bosh by 30 high, and made in twenty-three weeks of 1856 507 tons of forge metal out of "carbonite" ore from mines four to five miles southeast of furnace.

121.5. Hannah Steam Cold-blast Charcoal Furnace, owned by William Adams, Hannah Furnace P.O. Centre county Pennsylvania, and situated ten miles northeast of Tyrone Station towards Bellefonte and three miles south of Port Matilda, was built in 1828, received steam power in 1845, stopped in 1851, and stands in ruins.

122. Monroe Hot-blast Charcoal Furnace, owned by Gen. J. Irwin, and leased and managed by G. W. Johnson, Monroe Furnace P.O. Huntingdon county, Pennsylvania, standing on Shaver's Creek at the foot of Tussey Mountain, four miles (over the mountains) southeast from Pine Grove, and eighteen miles northeast from Spruce Creek station on the Pennsylvania railroad, was built in 1846, 8½ feet across the bosh by 33 feet high, and made in eighteen weeks of 1857 416 tons of chiefly forge iron out of (half) fossil ore within two miles southeast and southwest, and (half) rock ore from Ross' and Weaver's banks five miles distant to the north.

123. Huntingdon Hot-blast Charcoal Furnace, owned by G. and J. H. Shoenberger, and managed by Hays Hamilton, standing on Warrior Mark Run, four miles north of Spruce Creek station on the Pennsylvania railroad, was built in 1796, is 8 feet across the bosh by 32 feet high, and made in the year 1857 2,106 tons of metal out of brown hematite ore from sundry ore banks between one and four miles to the north of it.

124. Pennsyvlania Steam and Water Cold-blast Charcoal Furnace, Rockspring P.O. Huntington county Pennsyl-

vania, owned by Lyon, Short & Co. of Pittsburg, and situated on Spruce creek ten miles northeast from Spruce creek station on the Pennsylvania railroad, was built in 1813, and got steam-machinery in 1856. It is 8¾ feet across the bosh and 32 feet high and made in forty weeks of 1855 1,814 tons of forge metal out of brown hematite ores from its banks a mile northeast.

125. Brookland Steam and Water Hot-blast Charcoal Furnace, owned by the Juniata Iron Company, and managed by Daniel Holman, McVeytown Mifflin county Pennsylvania, standing half a mile northwest of McVeytown Station on the Pennsylvania railroad, was built in 1838 and changed in June of 1857 to cold-blast, 8 feet across the bosh by about 28 feet high. It made in about thirteen weeks of 1856 about 520 tons of metal out of brown hematite ore from Greenwood eight miles northwest, McVeytown twelve miles south by canal and Walter half a mile distant to the south-southwest.

126. Matilda Steam Hot-blast Charcoal Furnace, owned by J. Haldeman and situated less than two miles from Mount Union Station on the Pennsylvania railroad in Mifflin county. It is 8 by 33 feet stack, was built in 1838 and stopped in 1855, making that last half year about 700 tons.

127. Greenwood Cold-blast Charcoal Furnace, owned by J. A. Wright, is situated on the head waters of Standing Stone creek, on the road to Petersburg, fourteen miles northwest from Lewistown on the Pennsylvania railroad in Huntingdon county Pennsylvania. It was built in 1833; is 7½ feet across the bosh by 33 high, and made in 1856 1,284 tons of forge metal out of brown hematite pipe-ore from banks near Belleville in Kishicoquilis Valley mixed with red fossil ore obtained near the furnace in Stone Valley.

127.5. **Rebecca Furnace,** owned by Conkle's heirs, stands with its forge on Stone Creek three miles east of Saulsburg, three miles south of McAlvoy's Fort and twelve miles from Huntingdon, Huntingdon county Pennsylvania. It was abandoned about 1852; part of the bridge-house remains.

128. Mill Creek Steam and Water Hot-blast Charcoal Furnace, owned by James Irwin, Joseph Green, J. McCahan, and managed by John C. Watson, Huntingdon county Pennsylvania, situated on the waters of Mill Creek. five miles southeast of Huntingdon, an eighth of a mile east of the Pennsylvania Rail-

road and Canal and on the road from the Juniata River to Brown's Mills in Kishicoquilis Valley, was built in 1838, 8 feet across the bosh by 32 feet high, and made in forty-six weeks of 1857 1,101 tons of forge metal out of four-fifths brown hematite ore from banks three miles north of Spruce Creek Station and seventeen miles by railroad from the furnace.

129. Edward Hot-blast Charcoal Furnace, owned by the heirs of E. Bell, leased by Hugh McNeal, and managed by Jas. E. Foote Huntingdon county Pennsylvania, is situated one mile to the southeast of Vineyard Mills, (half mile southeast of the canal) on a run three-quarters of a mile below the mouth of Aughwick Creek, and on the road to Black Log valley, four miles southeast of Newton Hamilton Station on the Pennsylvania Railroad. It was built in 1839, is 8½ feet across the bosh by 32 feet high, and made in twenty-three weeks in 1856 713 tons of mostly foundry metal out of brown hematite ore from two miles west-northwest, on Owen's ridge, mixed with "dark metallic hematite," (cold-short) from a half mile southeast, and red fossil ore from a mine a hundred rods distant in the same direction.

129.5. Marion Furnace in Kishicoquilis Valley west of Lewistown was abandoned to ruin in 1841.

129.6. Jackson Furnace on Standing Stone creek seventeen miles above Huntingdon and one mile east of McAlevy's Fort was abandoned to ruin in 1852.

130. Rockhill Charcoal Furnace, owned by Robert Benson Wegton, Orbisonia P.O. Black Log, Huntingdon county Pennsylvania, and standing three-quarters of a mile southeast of Orbisonia, was built in 1830, is 8 feet across the bosh by 30 feet high, and has been running regularly for the last thirteen years making an average of 800 tons of metal per annum.

130.5. Winchester Furnace situated also in Black Log Gap two hundred yards northwest of Rockhill Furnace last described was abandoned to ruin in 1850.

130.6. Chester Furnace three miles from Orbisonia on the road to Mount Union is completely in ruins.

131. Malinda Cold-blast Charcoal Furnace, owned by J. & A. Sheffler, and managed by Thos. E. Orbison, Orbisonia P.O. Huntington county Pennsylvania, is situated on Aughwick Creek in Cromwell township fifteen miles southwest of Mount Union Station Pennsylvania Railroad, and near the State road

from Orbisonia to Three Springs. It was built in 1846, 6½ feet across the bosh by 30 high, was run only to supply the forge and has been out of blast since 1854 when a small blast of 100 tons of forge metal was made out of brown hematite ores from banks four miles north and near Jack's Mountain, four miles northeast near Orbisonia and five miles south.

132. Bald Eagle Steam and Water Cold-blast Charcoal Furnace, owned by Lyon, Shob & Co. of Pittsburg, and situated near the plank road five miles from Tyrone city station on the Pennsylvania railroad in Blair county, towards Bellefonte, was built in 1824 and furnished with steam-engine blast in 1857. It is 9 feet across the bosh by 32 feet high and made in thirty-six weeks of 1856 1,434 tons of forge metal out of brown hematite ores from the valley to the southeast three miles across the Bald Eagle Mountain.

133. Ætna Hot-blast Charcoal Furnace, owned by Isett, Keller & Co. situated in Blair county on the Pennsylvania Canal, twenty miles above Huntingdon and twenty-five below Hollidaysburg, one mile off to the southeast of the northern turnpike, was built in 1805, is 8 feet across the bosh by 31 feet high, and made in thirty weeks of 1855 1,021 tons of mostly forge metal out of brown hematite ore from banks two to four miles west, mixed with red fossil ore obtained from mines from five to seven miles distant.

134. Elizabeth Steam Hot-blast Charcoal Furnace, owned and managed by Martin Bell, Sabbath Rest P.O. Blair county Pennsylvania, situated on Beaver Dam Run in Logan's Valley one hundred rods east of its confluence with the Juniata, on a road five miles northeast of Altoona and two hundred rods east of the Pennsylvania Railroad, was built in 1832, is 9 feet across the bosh by 32 feet high, and made in twenty-six weeks of 1857 962 tons of foundry, car-wheel and forge metal out of brown hematite ore from a bank in a cove of Trenton limestone distant one mile south. This is said to be the first furnace that used the gas to create the steam in 1836.

135. Blair Steam Hot-blast Coke Furnace, owned by H. N. Burroughs, and managed by A. R. Stewart, stands on the Pennsylvania Railroad, two and a half miles northeast of Altoona Blair county Pennsylvania, was built in 1846, 8½ feet

across the bosh by 35 feet high, and made in forty weeks of 1856 1,134½ tons of metal mostly out of red fossil ore from the Frankstown mines eight miles southeast of it at the Brush Mountain Nose.

136. Alleghany Hot-blast Charcoal Furnace, owned and managed by Elias Baker and situated one and a half miles from Altoona, Blair county Pennsylvania, on the plank road to Hollidaysburg, opposite Mill Run Gap, was built in 1811, is 9 feet across the bosh by 32 feet high, and made in thirty-nine weeks of 1857 1,598½ tons of metal out of brown hematite ore from the deep bank four miles to the northeast, a half mile off the Pennsylvania Railroad to the southeast, and on the southeast side of the Upper Silurian Limestone ridge facing the Brush (Bald Eagle) Mountain; mixed with soft fossil ore.

137. Bennington (old Henrietta) **Steam Hot-blast Coke Furnace,** owned by the Blair county Iron and Coal Company, leased by Robt. M. Lemon, December 10, 1856 and managed by L. Lowry Moore, stands two miles east of the tunnel beneath the Pennsylvania Railroad as it ascends with a grade of ninety-two feet to the mile through Sugar Run Gap to the summit of the Alleghany Mountains and seven miles west from Hollidaysburg; was built about 1849 and restored in 1853, 9¾ feet across the bosh by 39½ high, and has lately used coke fuel with success, making 56 tons a week out of Frankstown red fossil ore mixed with bog ore found near the furnace. The lowest coal beds crop out behind the furnace.

138. Gaysport Steam Hot-blast Coke Furnace, owned by Watson, White & Co. and managed by D. Watson, standing opposite Hollidaysburg Blair county on the Pennsylvania Canal, was built in 1856, 13 feet across the bosh by 45 feet high, and made in forty-eight weeks of 1857 3,916¾ tons of foundry metal out of red fossil ore from mines near Frankstown.

139. Hollidaysburg (Chimney Rock) **Steam Hot-blast Coke Furnace,** owned by Gardner, Osterloh & Co. managed by A. M. Lloyd, and standing near the depot in Hollidaysburg Blair county Pennsylvania, was built in 1856, 13 feet across the bosh by 48 feet high, and made from the commencement of the first blast (Nov. 1856) to the end of the year, six weeks, 350

tons of foundry metal out of red fossil ore from mines three miles northeast in Frankstown township.

140. Frankstown Steam Hot-blast Coke Furnace, owned by Crawford and Higgens, and situated one and a half miles northeast of Frankstown, Blair county Pennsylvania, was built in 1836 and rebuilt in 1854, 10 feet across the bosh by 36 feet high, and made in forty-four weeks of 1856 about 2,300 tons of metal out of red fossil ore alone.

141. Gap (Martha) **Steam Charcoal Furnace,** owned by Shoenberger's heirs leased by Musselman and Barnitz, E. Freedom P.O. Blair county Pennsylvania, managed by Ed. S. Hughes, and standing in McKee's Gap, six miles southwest of Hollidaysburg, six miles west of Martinsburg on Cove Creek or Spang's Springs, three and a half miles by turnpike from Newry Sidling on the Portage Railroad, was built in 1846, is 9½ feet across the bosh by 32 feet high, used *anthracite** for its last blast in 1854, when it made perhaps 1,000 tons of metal out of red fossil ore from its own mines close by, mixed with some brown hematite.

142. Juniata Anthracite Furnace, situated in Williamsburg, and owned by Neff, Dean & Company, is 8 feet across the bosh and was built and began to make iron Christmas 1857, with anthracite coal,* at the rate of 60 tons a week, out of Frankstown fossil ore of Formation V.

142.5. Canoe Furnace on the Juniata Canal, one mile above Franklin Forge; owned by Isett, Keller & Co. has not been in use for ten years and is going to ruin; the stack stands but the machinery is removed; built about twenty years ago.

143. Springfield Hot-blast Charcoal Furnace, owned by D. Good & Co. managed by A. McAllister, and situated on Piney Creek in Morrison's Cove Blair county Pennsylvania, five miles south of Williamsburg, was built in 1815, is 8½ feet across the bosh by 30 feet high, and made in forty-six weeks of 1856 1,765 tons of metal out of brown hematite from banks two miles distant to the southeast.

144. Rebecca Steam Cold-blast Charcoal Furnace, owned by Ed. H. Lytle, managed by James Hemphill and P. Gallagher, and situated on Clover Creek, in Morrison's Cove

* Not mentioned in Table A.

Blair county Pennsylvania, on the Williamsburg and Stonerstown road and twelve miles southeast of Hollidaysburg, was built in 1819, is 9 feet across the bosh by 32 feet high, and made in twenty weeks of 1856 609 tons of forge metal out of brown hematite ores.

145. Bloomfield Cold-blast Charcoal Furnace, owned by J. W. Duncan and wife, managed by James Madard, and standing on the Hollidaysburg and Bedford road thirteen miles south of the former, at head waters of Quarrel Run in Morrison's cove Blair county Pennsylvania, was built in 1846, 9½ feet across the bosh by 32 feet high, and made in thirty-four weeks of 1856 1,100 tons of forge metal out of brown hematite ore from a bank three-quarters of a mile to the eastward of the stack.

146. Sarah Hot-blast Charcoal Furnace, owned by the heirs of Shoenberger, leased by D. C. McCormick, managed by M. Simpson, Claysburg P.O. Blair county Pennsylvania, and situated on Juniata Creek five miles west from Bloomfield Furnace last described in Morrison's Cove, thirteen miles from Hollidaysburg on the road to and twenty miles distant from Bedford, was built in 1831, and rebuilt in 1847, 8 feet across the bosh by 33 feet high, and made in forty-one weeks of 1856 1,473 tons of metal out of brown hematite ores from two banks four miles to the east of it, mixed with some fossil ore.

147. Lemnos Steam Charcoal Furnace, owned by John King & Co. and managed by Jno. B. Castner, stands on Yellow Creek two miles above its confluence with the Raystown Branch of Juniata, two miles west of Hopewell Bedford county Pennsylvania, on the plank road from Hopewell to Bloody Run; was built in 1841, is 8½ feet across the bosh by 30 feet high, and made in thirty-five weeks of 1855 736 tons of metal out of hematite ore from a bank two and a half miles north in Woodcock Valley, between Warrior Ridge and Coot Hill a spur of Tussey Mountain, mixed with red fossil ore from mines within two miles towards the west and eight miles towards the north on both sides of Coot Hill.

147.5. **Old Hopewell Furnace,** below the town of Hopewell on the Juniata, is abandoned. The new Huntingdon and Broad-Top railroad passed through its coal house.

148. Rough and Ready Cold-blast Charcoal Furnace,

owned by S. T. Watson & Co. Coffee Run P.O. Huntingdon county Pennsylvania, situated on Coffee Run twenty miles south of Huntingdon, and two miles east of the Huntingdon and Broad-Top Railroad, was built in 1849, is 9 feet across the bosh by 32 feet high, and formerly had a hot-blast. It made 20 tons a week until 1856 since when it has stood idle.

148.5. Paradise Furnace in Trough Valley five miles east of Rough and Ready Furnace has been out of blast since 1850.

149. Melville Hot-blast Charcoal Furnace, owned by R. D. Wood, and leased by R. D. Wood & Co. is situated on Maurice river in Cumberland county New Jersey, in the town of Millville, and ten miles east of Bridgeton; was built about 1815 and rebuilt in 1853, 9 feet across the bosh by 32 feet high; was regularly in blast until the fall of 1850 and has done little since 1854, when in twenty-one weeks 550 tons of foundry metal were made, out of bog ore found in the Tertiary deposits of the Atlantic seaboard, mixed with others from the State of Delaware near Milton and elsewhere.

149.1. Bergen Furnace in Monmouth county New Jersey is out of blast.

149.2. Hanover Furnace in Burlington county owned by Benjamin Jones has been idle five or six years.

149.3. Atsion Furnace in the same county owned by Mark T. Richards & Co. is out of blast.

149.4. Batsto Furnace below Atsion, on Little Egg Harbor River, has been idle four or five years.

149.5. Weymouth Furnace has been out five years.

149.6. Tuckahoe Furnace, Cape May county, has been idle a long time.

149.7. Cumberland Furnace, Cumberland county, owned by the heirs of Edward Smith, has been out of blast for fifteen years.

All these were Charcoal furnaces making mostly foundry metal out of the superficial deposits of bog ore and using the timber of the Jersey Pines. The Anthracite foundry iron manufacture has destroyed this branch of the Charcoal manufacture, but many of the large foundries attached to these furnaces continue to be used and have been increased in size.

149.8. Millsborough Charcoal Furnace, owned by Gardner H. Wright of Millsborough Sussex county Delaware is the only one in the State and has not made iron for ten years. A cupola furnace is in activity beside it.

149.9. Naseongo Charcoal Furnace, owned by Geo. S. Richardson of Snowhill and Geo. H. Marten of Philadelphia, and situated at the head of Naseongo creek five miles northwest of Snowhill, fifty miles south of Seaford, one mile above the Newton-Snowhill crossing, was built in 1830, a pretty large furnace, stopped in 1849 and now dilapidated.

150. Georgetown Steam Hot-blast Furnaces (two stacks, one without lining), owned by Wm. A. Bradley of Washington, D. C., stands on the east bank of the Potomac at the west end of Georgetown, was built about 1849, is about 8 feet across the bosh by 28 feet high, and was worked unsuccessfully until 1854 when it was abandoned and now is much dilapidated.

151. Blue Ridge Steam (?) Hot-Blast Charcoal Furnace, owned by Wilkins Glenn of Baltimore, and managed by Samuel B. Preston of Knoxville, Frederick county Maryland, stands on the north side of the Potomac River, a quarter of a mile below Knoxville station and four miles below Harper's Ferry; was built in 1849 and in 1855 abandoned; it is 12½ feet across the bosh by 40 high and made grey metal out of ores from Point of Rocks Furnace and from a bank up the Shenandoah. The shape is peculiar: Tunnel head 10 8 10 10 13 5½ 12 5½ 10 7 5 4 5 across hearth floor. It has 2 blast tubes, 4½ × 5 st. Engine 60 horse. Had 3 tuyères, now 6; formerly 4 in. noz., now 3; old ones 5½. (*Belongs to Table E.*)

152. Potomac Steam Hot-blast Coke Furnace, owned by J. W. Geary, and managed by Michael Mullen, Point of Rocks P.O. Loudon county, Virginia, stands on the Virginia bank of the river three-quarters of a mile below Point of Rocks, was built in 1839, rebuilt in 1846 and used charcoal until 1848, is 8 feet across the bosh by 30 high, has made no iron since 1854 but has received a larger engine and will average 60 tons per week, with brown hematite ores from a bank reached by a branch of the Baltimore and Ohio Railroad, which passes the furnace, three-quarters of a mile to the southeast.

153. Catharine Steam (?) Charcoal Furnace, owned by J. S. Wellford's heirs and others, Dr. Wellford, Executor, Brandy Station, Culpepper, Spottsylvania county Virginia, stands where the Fredericksburg and Valley Plank Road crosses Nye River, nearly ten miles due west of Fredericksburg, was built about 1837 and abandoned in 1846, the hematite ores used were from three banks within a half-mile of the furnace.

154. A New Steam (?) Charcoal Furnace, Robert Hard agent for the sale, Mansfield P.O. Spottsylvania county Virginia, is situated in Spottsylvania county about fifteen miles from Mansfield P.O. with 465 acres of land, timber and ore.

155. Rough and Ready Steam Cold-blast Charcoal Furnace, owned by Stephen Dunington of Tolersville P.O. Louisa county, Virginia, stands six miles east of Louisa Court House and a half mile west of north from Tolersville, was built in 1848, 9 feet across the bosh by about 40 high, and abandoned in 1853, used hematite ore from a bank two miles northeast mixed with magnetic ore from mines two miles west and one and a half miles east.

156. Hunter's Steam Cold-blast Charcoal Furnace, owned by John Hunter, leased by David and Samuel Anderson, and managed by Joel Yancy, is situated four miles northeast from Tolersville on the Central Railroad, was built in 1834, 9 feet across the bosh by 30 high, and made in thirty-four weeks of 1854 1,050 tons

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of metal from a brown hematite ore bank fifteen feet thick and well located. Furnace stack dilapidated.

157. Bear Garden Cold-blast Charcoal Furnace, situated a half mile southeast of New Canton, Buckingham county Virginia, was abandoned in 1840 and is now in ruins.

158. Elk Creek Cold-blast Charcoal Furnace, owned by Alex. Montgomery of Lynchburg, Campbell county Virginia, stands on Elk Creek in Nelson county eight hundred yards north of James River and Canal, and twenty-five miles north of Lynchburg, was abandoned in 1850 and is much out of repair, has a *round* stack 9 feet across the bosh by 30 high, and used mixed brown hematite and magnetic ore from banks and mines to the north and west of furnace.

159. Stonewall Charcoal Furnace, situated on Stonewall Creek in Appomatox county, two miles from James River, and about fifteen miles north of Lynchburg was abandoned about 1845 and is now in ruins.

160. Lagrange Charcoal Furnace, (once William Ross Furnace) on Stonewall Creek, one mile above Stonewall Furnace, and sixteen north of Lynchburg, was abandoned about 1843 and has disappeared.

161. Oxford Charcoal Furnace, once Old Davie Ross Furnace, stood on Beaver Creek, seven miles south of east from Lynchburg, was abandoned about 1837 and has disappeared.

162. Saunder's Charcoal Furnace, situated at Franklin Court House, Virginia, was abandoned 1800 and is now in ruins.

163. Carron Cold-blast Charcoal Furnace, owned by Peter and Robt. J. Saunders, Franklin Court House P.O. Franklin county Virginia, is situated seven miles west of Franklin C.H. on Stony Creek, three miles southwest of Valley Forge, twenty-two miles east of Floyd C.H. and thirty-two northeast of Patrick C.H. was built in 1857, 8 feet across the bosh by 30 feet high and is to use hematite ore like that of Union Furnace, but more sulphurous, three miles south.

164. Union Cold-blast Charcoal Furnace, owned by Samuel W. Hairston, Union Furance P.O. Patrick county Virginia, is situated on Hales' Creek, twenty miles east of north from Patrick C.H. twenty-five west of south from Franklin C.H. twenty east of Floyd C.H., about five miles from Franklin county line, fifty-five from Danville and about fifty from Big Lick the nearest station on Virginia and Tennessee Railroad; was built about 1836, is 9 feet across the bosh by 30 high and made in six months of 1854 about 500 tons of mostly forge metal out of blue lump ore from a quarter of a mile north

mixed with hard red lump and fine bluish, purple, black and red ores from the same spot.

165. West Fork Cold-blast Charcoal Furnace, owned by Robt. L. Toncray, West Fork P.O. Floyd county Virginia, stands on the West Fork of Little River, twenty-five miles above Snowville, twenty west of Patrick C.H. and eight southeast of Jacksonville; was built in 1853, 6 feet across the bosh by 28 feet high, and has made nothing since Christmas 1855 and only about 150 tons per annum previously.

166. Poplar Camp Charcoal Furnace, situated in Wythe county, Virginia, on a small stream emptying into New River, 2 miles above its mouth and 8 miles west from Barren Spring Furnace; was abandoned between the years 1817 and 1827, and nothing now remains.

167. Shelor's Charcoal Furnace, situated close by West York Furnace in Wythe county, Virginia, was abandoned long ago and a few traces alone mark its site.

168. Another Furnace stood close by Shelor's and West York Furnaces, which was built before either of the last. No remains.

169. Another old Furnace, in Grayson county, on Fox or Meadow Creek, 12 miles north from Little River forge, and three miles southeast from Independence, was abandoned in 1845, and nothing of it remains.

170. Shannondale Steam and Water Charcoal Furnace, owned by C. Brooke of Wagontown, Chester county Pennsylvania, and leased by John West, is situated in Jefferson county Virginia, six miles east of Charlestown; was built in 1837, with a 9 foot bosh and made in 1855 perhaps 250 tons of iron out of ore from a mine two miles down the river, and stopped January 1, 1857.

171. Taylor Steam Hot-blast Charcoal Furnace, owned by James Been, Mountain Falls P.O. and formerly leased by S. A. Pancoast, Pawpaw P.O. Frederick county, Virginia, stands ten miles west of Winchester, was built about 1845, is 8 feet wide across the bosh by about 32 feet high, and made in 1855 perhaps 500 tons of metal out of brown hematite ore.

172. Zane's Charcoal Furnace, situated on Cedar Creek, Frederick county Virginia, was "built before any iron works in this region," and is now in ruins having been abandoned about the year 1828. Has a forge attached also in ruins.

173. Bloomery Water and Steam Hot-blast Charcoal Furnace, owned by C. H. Pancoast and J. Magee, 403 Walnut street Philadelphia, and formerly leased by S. A. Pancoast, is

situated in Hampshire county Virginia, was built about 1844, is 7 feet across the bosh by about 30 high, and made in thirty-five weeks of each of the last three years about 800 tons of metal.

174. Vulcan Steam Hot-blast Charcoal Furnace, owned by C. H. Pancoast, leased by the New Creek Coal Company, T. S. Richards, agent, Cumberland P.O. Maryland, is situated in Hampshire county Virginia nine miles southeast of Cumberland Maryland; was built about 1847, 9 feet across the bosh by 33 high, and was out of blast about seven years. It formerly made forty tons a week out of red fossil ore (Formation V.) but is blown in again on coke and coal measure carbonate, fossil and brown hematite ores mixed.

175. McCarty Charcoal Furnace which stands by the Paddington Railroad station in Hampshire county Virginia is still standing, but has made no iron for 30 years, and everything is removed.

176. Capon Hot-blast Charcoal Furnace, owned and managed by J. J. Keller of Wardensville P.O. Virginia, is situated three miles from Wardensville, on the Cacapon River at the crossing of the Winchester and Moorefield turnpike, and thirty-six miles west of the former; was built in 1822, is 9 feet across the bosh by 30 high, and made an average of about 300 tons of metal in about sixteen weeks of each of the three years past, out of brown hematite ore from banks one and a half mile west.

177. Bryan's Charcoal Furnace, on Hezekiah Cleggit's farm in Hardy county, Virginia, was abandoned about 1840 and is in ruins.

178. Trout Run Charcoal Furnace, is situated in Trout Run Valley, in the Devil's Hole, Hardy county, Virginia, seven miles southeast of Wardensville and was formerly called Crackwhip Furnace; it is now in ruins.

179. Fort Steam and Water Hot-blast Charcoal Furnace, once Fort's Mouth Furnace, afterwards Elizabeth Furnace, owned and managed by Gilease and Brown, Front Royal, Strasburg P.O. Warren county Virginia, stands on Passage Creek, two and a half miles above Fort's Mouth Forge, 25 miles below Luray, 15 miles below Caroline Furnace, and within 4½ miles south of the Manassah Gap and eight and a half miles southeast of Strasburg. It was built in 1836, 9 feet across the bosh by 33 feet high, and makes about 250 tons a year out of brown hematite ore from a quarter of a mile west of the furnace.

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180. Paddy Hot-blast Charcoal Furnace, owned and managed by Mr. Wilson of New York city, situated in and on the borders of Shenandoah county Virginia, seven miles west of Strasburg, was built in 1833, 8 feet across the bosh by 33 feet high, and produced 25 to 30 tons a week out of cold short brown hematite ore from banks one mile west and southwest, mixed with bog ore from three-quarters of a mile due west,—previous to the summer of 1851.

181. Columbia Cold-blast Charcoal Furnace, owned by Wissler and (Samuel) Myers, Columbia Furnace P.O. Shenandoah county, Virginia, situated eight and a half miles southwest of Woodstock, on Stony Creek, 6 miles west of Edinburg, 4 miles above (west of) Union Forge, was built in 1810, rebuilt in 1823, and for 15 years until April 1854, ran regularly 11½ months in each year, making 700–800 tons a year. It is 8½ feet across the bosh by 30 high and made in thirty-six weeks of 1855 850 tons of forge and foundry metal out of brown hematite ore from Five Mile bank five miles northwest, Three Mile bank three miles southwest, Drummond's bank two miles west, and also formerly from Black Oak bank two miles west.

182. Van Buren Steam Hot-blast Charcoal Furnace, No. 1, owned by Miller and Mayhew of Baltimore, and last managed by Mr. James, stands on Cedar Creek seven miles west of Woodstock in Shenandoah county Virginia; was built in 1837 and reduced in width of bosh in 1854 to 8¼ feet by 32 feet high, and made in 1855 about 500 tons of cold short metal out of brown hematite ore from banks within two thousand yards around,—and nothing since.

183. Van Buren Cold-blast Charcoal Furnace, No. 2, stands forty rods to the east of No. 1, and is owned by James W. Farrer, Van Buren P.O. Shenandoah county Virginia. Built by Lorenzo Seibert in 1850 only 3 feet across the bosh for making malleable iron direct from the ore, and about 22 feet high, it ran ten days, chilled up and stands as it was left.

184. Caroline Cold-blast Charcoal Furnace, owned by Marston, Bush & Co. of Wilmington, Delaware, and managed by J. Marston, Edinburg, Shenandoah county Virginia, stands eight miles southeast of Edinburg and twelve of Woodstock; was built in 1835, is 9 feet across the bosh by 30 high, and made in twenty-two and a half weeks in 1856 553 tons of

forge and foundry metal out of "yellow and black oxide" ores from the mountain one and a quarter miles distant on the Luray road, mixed with one quarter part red fossil ore from a bank two and a quarter miles northwest on the side of the Alleghany Mountain.

185. Liberty Cold-blast Charcoal Furnace, owned by Walter Newman, and managed by Benjamin P. Newman, Liberty Furnace P.O. Shenandoah county Virginia, stands on a branch of Stony Creek, twelve miles west of Woodstock, eleven north of Edinburg and five west of Columbia Furnace; was built in 1821, is 8 feet across the bosh by 30 high, and made in twenty weeks of 1855 387 tons of foundry metal out of hematite ore from banks one mile north.

186. Isabella Cold-blast Charcoal Furnace, owned by Nicholas W. Yager of Luray, Page county Virginia, one mile north of Luray, on Hawksbill Creek a half mile above Speedwell Forge No. 1, was built about 1760, and abandoned in 1841, now in ruins.

187. Catharine Cold-blast Charcoal Furnace, owned and managed by John McKiernan, Alma P.O. Page county Virginia, situated three miles west of Newport, fourteen miles from Luray, fifteen by pike from New Market, and eighteen by bridle path and twenty-five by road from Harrisburg, was built in 1846, 8 feet across the bosh by 32 feet high, and made in twenty-two weeks of 1856 526 tons of metal out of brown hematite ore from banks three-quarters of a mile west of north from the furnace.

188. Shenandoah Cold-blast Charcoal Furnace, No. 1 leased and formerly owned by D. and H. Forrer, and managed by H. Pope, Shenandoah Iron Works, Page county Virginia, stands nine miles southwest of Newport, twenty south of Luray and twenty-three south of Harrisburg; was built in 1836, 9 feet across the bosh by 33 feet high, and made in twenty-two weeks of 1856 632½ tons of forge metal out of brown hematite ore from banks in Rockingham county, within a quarter of a mile of the furnace.

189. Shenandoah Steam Hot-blast Charcoal Furnace No. 2, leased and owned like No. 1, stands on Naked Creek, five miles above Furnace No. 1 and twenty miles above Port

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Republic, was built in 1857, about 9 feet across the bosh by 36 feet high, to make 50 tons a week.

190. **Margaret Jane Steam and Water Hot-blast Charcoal Furnace,** owned and managed by John Miller, Port Republic P.O. Rockingham county Virginia, is situated in Brown's Gap, three miles east of Mount Vernon Forge and three miles northeast of Port Republic; was built in 1849, 8 feet across the bosh by 31 feet high, and made in twenty-six weeks of each of the three years before 1857 about 750 tons of forge metal out of brown hematite pipe ore from a bank near the furnace, mixed with ores from three and five miles north at the foot of the mountain.

191. **Oakland Charcoal Furnace,** situated a half mile east of Brock's Gap in Rockingham county Virginia was built by Mr. Pennebacker, living near New Market, about 1837 and within the same year abandoned and is now in ruins.

192. **An old Furnace** in Rockingham county Virginia, on Smith's Creek, built, some say 70 years ago, was abandoned 40 or more years ago.

193. **Elizabeth (?) Furnace.**

194. **Mossy Creek Cold-blast Charcoal Furnace,** owned by Daniel Forrer, Mossy Creek P.O. Augusta county Virginia, is situated eleven miles from Harrisburg, fourteen miles northwest of Staunton, and two and a half miles from Manassah Gap Railroad; was built about 1760, is about 8½ feet across the bosh by 28¼ high; was burnt down in 1841 and is now in a ruined condition; the ores lie in all directions around it.

195. **Mount Torry Hot-blast Charcoal Furnace,** owned and managed by Lorenzo Shaw, Waynesborough P. O. Augusta county Virginia, stands on Back Creek, fifteen miles east of Greensville, about eighteen northeast of Cotopaxi Furnace, and sixteen west of south from Waynesborough; was built in 1800, and rebuilt in 1853; is 11 feet across the bosh by 35 feet high, and made in the half year of 1854 about 700 tons of cold-short metal out of brown hematite ore from a bank two miles northwest, but has made nothing since the spring of 1855.

196. **Canada Charcoal Furnace,** a very small stack situated in Augusta county Virginia, 3 miles west-northwest of Mount Torry Furnace, built 40 years ago, blew but a few days and is a heap of ruins.

197. **Estelline Cold-blast Charcoal Furnace,** owned and managed by Lorenzo Shaw, Waynesborough P.O. Augusta county Virginia, situated twenty-one miles west of Staunton, on the head waters of Little Calf Pasture, three miles west of south

from Pond Gap Station (18 m. west of Staunton), one and a half south of the Virginia Central Railroad and three miles southeast of Craigsville (22 west of the Station), was built about 1838, 6 feet across the bosh by 32 feet high, and made in 1855 and '56, each year about thirty weeks, 20 tons of cold short metal per week out of brown hematite ore from banks two miles southeast.

198. Cotopaxi Hot-blast Charcoal Furnace, owned and managed by John and Isaac Newton, Greenville P.O. Augusta county Virginia, situated on South River four miles above Vesuvius Furnace, and sixteen miles southwest of Staunton, was built about 1836, is about 8 feet across the bosh by about 32 feet high, and made in about thirty-two weeks of 1854, previous to its abandonment on the 23d December, about 600 tons of metal out of brown hematite ores from Morris bank one mile south, and Bear's bank three miles northeast. It is now in ruins.

199. Vesuvius Cold-blast Charcoal Furnace, owned and managed by Bradley and Donald, Steele's Tavern P.O. Rockbridge county Virginia, stands on South River, twenty miles southwest of Staunton; was built in 1828, is 8 feet across the bosh by 40 feet high and was abandoned on the fifteenth of December 1854, making in twenty-six weeks of that year about 600 tons of metal out of "black rock" hematite ores from several banks within three miles. The furnace is now dilapidated.

200. Buena Vista Hot and Cold-blast Charcoal Furnace, owned by Sam. F. Jordan, and managed by Jno. J. Jordan, Buena Vista P.O. Rockbridge county Virginia, standing on South River, one and a half miles from North River, 8 miles north of Buffalo Forge, 15 miles below (southwest) Vesuvius Furnace, and six miles east of Lexington, was built in 1847, 9 feet across the bosh by 33 feet high, and made in an average of each of the years 1854 '55 and '56 about 900 tons of metal out of brown hematite ore from Cash's and Hayes' Old bank, within three miles southeast.

201. Glenwood Cold-blast Charcoal Furnace, owned by Francis T. Anderson, and managed by E. Peck, Balcony Falls P.O. Rockbridge county Virginia, stands in Arnold's Valley 1½ miles south of James River, and eighteen miles southeast of Lexington; was built in 1849, 9 feet across the bosh by 38 feet high, and made in twenty-eight weeks of 1856 940 tons of metal out of brown hematite ore from Greenlee bank one mile off to the north.

202. California Steam and Water Hot-blast Charcoal Furnace, owned by John W. Jordan Alum Springs P.O. Rockbridge county Virginia, standing on Bratton's Run, fifteen miles

west of north from Lexington, two miles southeast of the Springs, was built in 1850, 9 feet across the bosh by 36 feet high, and made in eighteen weeks of 1855 1,076½ tons of cold short metal out of brown hematite ore from banks two and a half miles distant to the west of south.

203. Mount Hope Charcoal Furnace, situated a quarter of a mile above California Furnace, on the same stream, was built about 1849, abandoned in 1853, and is not much dilapidated.

204. Panther Gap Charcoal Furnace, situated in Rockbridge county Virginia, one and a half miles west of Goshen on the Virginia Central Railroad, was abandoned about 1837 and is now a heap of ruins.

205. Bath Iron Works Furnace, formerly owned by Wm. Weaver of Buffalo Forge, situated close to the Goshen station on the Virginia Central Railroad, was built in 1824 or '25 and rebuilt in 1830. The forge was built in 1827 and both were abandoned in 1850.

206. Moore's Charcoal Furnace standing on the banks of Steele's Creek in Rockbridge county Virginia, was abandoned thirty or forty years ago and is in ruins.

207. Dolly Ann Steam and Water Hot-blast Charcoal Furnace, owned by B. J. Jordon & Co. and managed by W. H. Jordan, was called for a time Rough and Ready Furnace, and stands three and a half miles east of Covington, on Pounding Mill Run, one and a half miles distant from the Virginia Central Railroad line and from the James River and Kanawha Canal. It was built in 1848, rebuilt and enlarged in 1854, to 8½ feet across the bosh by 36 feet high, and made in sixteen weeks of 1856 about 500 tons of metal out of hematite ore found at the furnace.

208. Lucy Salina Charcoal Furnace, owned by E. & J. F. Jordan, situated in Alleghany county Virginia, on Simpson's Creek, four and a half miles west of Australia Furnace, next to be described, and twenty-one miles east of Covington, was built in 1827, abandoned in 1852, and is dilapidated.

209. Australia Steam and Water Hot-blast Charcoal Furnace, owned by E. & J. F. Jordan, Cow Pasture Bridge P.O. Alleghany county Virginia, situated twenty-five miles east of Covington, on Simpson's Creek, twelve miles southeast of Clifton Forge and thirty-six miles north of Buchanan, was built in 1854, 11 feet across the bosh by 40 high, and made in about thirty-three weeks of 1856 915 tons of metal out of brown hematite ore from banks six hundred yards northwest.

210. Clifton Cold-blast Charcoal Furnace, owned by Wm. L. Alexander, Clifton Furnace P.O. Alleghany county Virginia, situated thirteen miles east of Covington, on Jackson's River at Clifton Forge, four miles east of Jackson's River station on the Virginia Central Railroad, was built in 1846, 9 feet across the bosh by 33 feet high, and made in twenty-nine weeks of 1854 about 800 tons of metal, making nothing since, out of fifty per cent. hematite ore from banks one mile east and west.

211. Rumsey Iron Works Charcoal Furnace, owned by the Jordans, stands on Dunlap's Creek and was abandoned about 1854 and nothing now remains.

212. Roaring Run Hot-blast Charcoal Furnace, owned by F. B. Deane of Lynchburg and Samuel C. Robinson of Richmond, Virginia, situated on Roaring Run, a branch of Craig's Creek, four miles southwest of Dibbrell's Sulphur Springs, thirty-six miles northwest of Bonsack's station on the Virginia and Tennessee Railroad and forty miles south of west from Lexington, was built about 1832, rebuilt in 1847, 8½ feet across the bosh by 36 (?) feet high, and made in thirty-five weeks of 1854 about 800 tons of metal out of brown hematite ore from a bank one mile distant south; was abandoned in December 1854 and is now dilapidated.

213. Grace Steam Cold-blast Charcoal Furnace, owned by Shanks and Patton, and managed by Thomas Cornelius, Grace Furnace P.O. Botetourt county Virginia, situated on Craig's Creek seventeen miles southeast of Covington and 17 miles west of Fincastle was built in 1849, 8½ feet across the bosh by 33 feet high, and made in about twenty-six weeks of 1856 about 900 tons of metal out of brown hematite ore from two banks within a hundred yards of the furnace, mixed with other neighboring ores.

214. Rebecca Cold-blast Charcoal Furnace, owned by the heirs of W. Wilson, D. J. Wilson, Daggert's Springs P.O. Botetourt county Virginia, is situated fifteen miles northwest of Buchanan, one mile east-southeast of Daggert's Springs, and two miles northeast from James River, 15 miles northwest of Buchanan; built 35 to 40 years ago; was abandoned about 7 years ago, and is dilapidated.

215. Jane Cold-blast Charcoal Furnace, owned by the heirs of Wm. Wilson. is situated four miles northeast of Rebecca Furnace last described, and sixteen miles northwest of Buchanan. It was built 25 to 30 years ago and abandoned about 1850, and is more dilapidated than Rebecca.

216. Retreat Charcoal Furnace, owned by Colonel William Weaver, situated on Purgatory Creek, in Botetourt county Virginia, nine miles north of Buchanan, was built about 1827, and abandoned about 1849, and is now in ruins.

217. Cloverdale Charcoal Furnace, No. 1, last owned by General Taylor, situated eighteen miles southwest of Buchanan, on the macadamized Valley Turnpike, 10 miles south of Fincastle, was built about 1830 and abandoned about 1849.

218. Cloverdale Cold-blast Charcoal Furnace, No. 2, owned by Anderson and Patton of Pattonsburg P.O. and managed by T. H. Burns, Blue Ridge, situated on Back Creek in Botetourt county, seven and a half miles southeast of Buchanan, five miles south of James River, eight east of Fincastle, at the western base of the Blue Ridge, 200 miles from Richmond, was built in 1841, rebuilt in 1850, and again rebuilt in 1854, 9 feet across the bosh by 37 feet high and has averaged about the same yield for years making in thirty-two weeks of 1856 1,120 tons of metal out of brown hematite ore from McFallon's bank three miles south, and Campbell's banks one mile east.

119. Ætna Hot-blast Charcoal Furnace, owned by Wm. Weaver, and managed by Charles K. Gorgas, and W. W. Rex, Pattonsburg, Botetourt county Virginia, situated on Purgatory Creek, two and a half miles northeast of Buchanan, and fourteen miles north of east from Fincastle, was built in 1792, and rebuilt in 1842, 9 feet across the bosh by about 35 feet high, and made in twenty two weeks of 1856 700 tons of metal out of brown hematite ore from Retreat bank six miles by wagon road, ten miles by railroad, distant to the north, mixed with "lump" ore from a bank three hundred yards west of furnace.

220. Catawba Charcoal Furnace, situated on Catawba Creek in Botetourt county Virginia, eleven miles west of Fincastle, was built about 1830, abandoned in 1849 and is now dilapidated.

221. Harvey's Charcoal Furnace, situated in Botetourt county, was built about 1810, abandoned about 1825 and is now entirely gone.

222. An Old Furnace, situated in Craig county Virginia, on Craig's Creek, one and a half miles above New Castle, was built about 1830, abandoned about 1843, and is now entirely gone.

223. Barren Spring Cold-blast Charcoal Furnace, owned by David Graham of Graham's Forge, and managed by Charles W. Lyons, situated on the south bank of New River, in Wythe county Virginia, eighteen miles southeast of Wytheville, six miles by road southeast from Graham's Forge, about fifteen north of Hillsville, and twelve miles on a good road from Mac's Meadows Depot on the Virginia and Tennessee railroad, was

built in 1854, 7 feet across the bosh by 40 high, and made in twenty-six weeks of each of the years 1855 and '6, an average of 450 tons of metal each year, out of brown hematite ore from banks three-quarters of a mile southeast and three hundred yards southeast.

224. **Wilkinson's Cold-blast Charcoal Furnace**, owned by James Wilkinson of Brown Hill P.O. Wythe county Virginia, standing on Cripple Creek a quarter mile below Forge No. 3, and twelve miles west of south from Wytheville, was built about 1810 by Bell & Kincannon, and abandoned by them 30 years ago. An attempt was made in 1856 to blow it in, but it chilled, was abandoned, and remains in a dilapidated state. It used brown hematite ore from a bank four miles west.

225. **Parry Mount Charcoal Furance**, No. 1, standing four hundred yards west of No. 2, and three miles southeast of Graham's Forge, was built about 1800, abandoned in 1832 and is now a ruin.

226. **Parry Mount Charcoal Furnace**, No. 2, owned by David Graham of Graham's Forge P.O. situated on the road from Graham's Forge to Barren Spring Furnace, in Wythe county Virginia, was built in 1832, supplied the forge, was abandoned in 1852 and is now dilapidated.

227. **Porter's Charcoal Furnace**, standing on a little stream which empties into Cripple Creek four miles above its mouth and four miles southwest of Wilkinson's Furnace, was built thirty or forty years ago, abandoned 1849 '50, and is now in ruins.

228. **Paulina Cold-blast Charcoal Furnace**, owned by James Brown of Abingdon, situated on Valley Creek, in Washington county Virginia, three miles southwest of Brown's Forge one hundred yards south of the South Fork of Holsten, was built about thirty years ago, 9 feet across the bosh by 30 high. The old stack still stands and the cupola attached is still in use.

229. **White's Charcoal Furnace**, owned by Wm. & Newton White of Abingdon, situated on the north fork of Holsten River, in Washington county Virginia, fifteen miles southwest of Saltville, was abandoned more than twenty years ago and is now all gone.

230. **Rehoboth Cold-blast Charcoal Furnace**, owned by F. M. Reinhardt & Co. and managed by F. M. Reinhardt, Lincolnton P.O. Lincoln county North Carolina, and standing on Leiper's Creek, eight miles south of east from Lincolnton, and twenty-five miles northwest of Charlotte, was built in 1814, is 7 feet across the bosh by 34 feet high, and made in eighteen weeks of 1856 200 tons of foundry metal out of 400 tons of magnetic ore from the "iron bank" on Leiper's Creek.

231. **Madison Cold-blast Charcoal Furnace**, owned by James F. & R. D. Johnston, and managed by J. F. Johnston, Lincolnton P.O. Lincoln county North Carolina, and standing

on Leiper's Creek three miles above Rehoboth Furnace last described, and six miles east of Lincolnton, was built in 1809, and rebuilt in 1855, 6 feet across the bosh by 30 high, and made in 1849 225 tons of foundry metal out of magnetic ore from the "iron bank" one and a half miles distant.

232. Vesuvius Cold-blast Charcoal Furnace, owned and managed by A. F. & E. J. Brevard, Cottage Home P.O. Lincoln county North Carolina and standing on Anderson's Creek, four miles northeast from Madison Furnace last described and ten miles east of Lincolnton, was built in 1795, rebuilt about 1843, 6 feet across the bosh by 30 high, and made in twenty weeks of 1856 250 tons of foundry metal out of black magnetic ore.

233. Columbia Charcoal Furnace, owned by the High Shoals Mining and Manufacturing Company, office No. 4 Bowling Green, New York, agent Thomas Darling, Nail Factory P.O. Gaston county North Carolina, and situated seven miles west from High Shoals, eight and a half northwest of Dallas Court House, is in ruin; has not operated since January 1, 1854. Expect it to be restored and operated again together with the rolling mill and forges. Ore nickeliferous magnetic near by.

234. Tom's Creek Charcoal Furnace, situated in Surrey county, North Carolina, on Tom's Creek, near Hill's Forge, was destroyed by the flood of 1850 and is now in ruins.

235. Buffalo Creek Charcoal Furnace, situated in Cleveland county North Carolina, on Buffalo Creek, and near Buffalo Forge, was in blast before the Revolution but is now in total ruins.

236. Hurricane Cold-blast Charcoal Furnace, owned by the South Carolina Manufacturing Company, Simpson Bobo agent, Spartanburg P.O. Spartanburg district South Carolina, and situated on Pacolet River, seven miles north of east from Spartanburg, was built in 1834, 7 feet across the bosh by 40 high, and has averaged in twenty-eight weeks of each past year 230 tons of foundry metal out of brown hematite ore from banks four miles northeast.

237. Cowpens Cold-blast Charcoal Furnace, owned by the same parties as Hurricane Furnace last described and situated on Cherokee Creek, fourteen miles east of north from Spartanburg and three miles south of the State-line and five miles

east from the Battle Field, was built in 1807 and rebuilt in 1834, 7 feet across the bosh by 30 high, and has made in thirty-five weeks of each year since 1853 about 450 tons of forge metal out of brown hematite ore from a bank near the Hurricane ore banks.

238. North Twin Cold-blast Charcoal Furnace, owned by the Swedish Iron Manufacturing Company, and managed by A. M. Latham, Cooperville P.O. Spartanburg district South Carolina, and standing on Broad River, twenty-six miles north-east from Spartanville and twenty-four miles west of north from Yorkville, was built in 1841, 9 feet across the bosh by 36 feet high, and made in twenty-eight weeks of 1855 476 tons of metal for the rolling mill out of a mixture of black magnetic and brown hematite ores.

239. South Twin Cold-blast Charcoal Furnace, owned and managed by the same parties, standing alongside of and joined to North Twin, was built in 1837, to run alternately with North Twin and made in forty-eight weeks of 1856 816 tons of metal for the rolling mill out of the same brown hematite and magnetic ores mixed.

240. Cherokee Charcoal Furnace, owned by the Cherokee Iron Manufacturing Company, and situated at the Cherokee Iron Works, two and a half miles below the Swedish Iron Works, was built in 1837, ran one year, and has ever since remained out of repair.

241. Ellen Cold-blast Charcoal Furnace, owned by the Swedish Iron Manufacturing Company and standing two miles up People's Creek above its mouth, was built in 1837, 9 feet across the bosh by 28 feet high and went out of blast about 1850, and has been out of repair since 1852.

242. Susan Cold-Blast Charcoal Furnace, is situated on People's Creek, in Union District, one mile from Ellen Furnace, last described, having the same age and history as it, 9 feet across the bosh by 34 feet high.

243. King's Creek Charcoal Furnace, owned by the King's Mountain Iron Company, M. M. Montgomery, agent, Cherokee Works, and situated on King's Creek in York District, four miles from its junction with Broad River, and seven miles east of the Rolling Mill, is likewise abandoned.

244. Sequee Charcoal Furnace, situated on Sequee Creek 3 miles South of Clarkesville, Habersham county Georgia, was built in 1832 or earlier, and abandoned about 1837, and is now in ruins.

245. Allatoona Hot-blast Charcoal Furnace, owned by T. F. Moore and D. R. Thomas of Allatoona P.O. Cass county

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Georgia, and standing on Allatoona Creek, thirteen miles southeast of Cassville three miles from the Mississippi and Atlantic railroad and six miles east-southeast of Cartersville, was built in 1844, 7 feet across the bosh by 30 feet high, and made in twenty-two weeks of 1856 375½ tons of foundry metal out of brown hematite and black oxide ores from several banks within two miles around. Previous to 1855 it had no cold-blast.

246. Etowah Cold-blast Charcoal Furnace, owned by the Etowah Manufacturing and Mining Company, M. A. Cooper, President, managed by T. M. Stocks, and situated on Stamp Creek in Cass county Georgia, two miles northeast of Etowah Rolling Mill and six miles northeast of Allatoona Railroad Station, was built in 1844, 8 feet across the bosh by 30 high, and made in about forty-four weeks of 1856 779¼ tons of metal out of brown hematite ore from banks four miles southwest. Old Etowah Furnace built 1837, abandoned 1844, torn down 1850, stood alongside of the present furnace.

247. Pool Cold-blast Charcoal Furnace, owned by B. G. Pool and J. W. Lewis of Cartersville, managed by B. G. Pool, Etawah, Cass county Georgia, and standing on Stamp Creek, ten miles east by south from Cartersville Station, eight miles above or north of Etowah Furnace, and twelve miles southeast of Cassville, was built in 1855, 8 feet across the bosh by 33 feet high, and made in fifteen weeks of 1856 316 tons of metal from red hematite ore from Big Spring bank three miles west and Peach Tree bank three miles distant to the northwest.

248. Union Cold-blast Charcoal Furnace, owned by D. S. and A. M. Ford, Cartersville P.O. Cass county Georgia, stands on Stamp Creek, nine miles east by north of Cartersville Station, two miles northwest (above) Pool Furnace, twelve miles southeast of Cassville, on the road to Canton, fifteen miles from Canton, was to have a *hot-blast* after Christmas 1857; was built in 1852, 7½ feet across the bosh by 30 feet high, and made in twenty-three and a half weeks of 1856 536 tons of metal out of brown (?) hematite and black oxide ores from several banks within two miles northwest.

249. Lewis' Cold-blast Charcoal Furnace, owned by Dr. J. W. Lewis, of Cartersville, leased and managed by Lewis

& (T. A.) Jones, and situated on Stamp Creek, one mile above Union Furnace, ten miles east by north from Cartersville Station, and in Cass county, Georgia, was built about 1847, $7\frac{1}{2}$ feet across the bosh by 26 feet high, and made in about thirty weeks of 1856 about 400 tons of metal out of brown hematite ore from its own Big Bank two miles distant northwest, mixed with ore from Peach Tree bank two miles west.

250. Cartersville Cold-blast Charcoal Furnace, owned by the heirs of Henry and Arnold Milner, Wm. Milner executor, and managed by H. Milner, and standing on Pettit's Creek, six miles south of Cassville and two and a half miles north of Cartersville Station, was built in 1852, $7\frac{1}{2}$ feet across the bosh by 32 feet high, and made in about seventeen weeks of 1856 about 400 tons of metal out of brown hematite ore from Foster's, Fullmore's, Giton's and Milner's banks three miles northeast and east.

251. Clear Creek Cold-blast Charcoal Furnace, owned by Wm. N. Bishop of Tunnel Hill P.O. Whitefield county, and situated in Walker county, Georgia, twelve miles east of La Fayette, on Clear Creek, a branch of the Armuchy, five miles east of its mouth, and fourteen miles west of Resaca, was built about 1852 by A. J. Stroup, and rebuilt by the present owner in 1857 8 feet across the bosh by 24 feet high, and made in thirteen weeks of 1855 about 237 tons of metal out of red fossiliferous ore (Formation V. Clinton or Upper Silurian) from Taylor's Ridge six miles west, mixed with brown hematite from Snake Creek banks eight miles east and also gravel ore from one and a half miles south.

252. Round Mountain Steam Hot-blast Charcoal Furnace, owned and managed by Samuel P. L. Marshall, Blue Pond P.O. Cherokee county Alabama, and standing a half mile from the Coosa River, five miles southwest of Cedar Bluff, and five miles north of Centre, was built in 1852, $7\frac{2}{3}$ feet across the bosh by 32 feet high, and has made during the three years previous to 1857 an average of 11 tons per week of metal out of red fossil ore from mines two hundred yards west of furnace.

253. Polkville Hot-blast Charcoal Furnace, owned by Goode, Morris & Co. Morrisville P.O. Benton county Alabama, standing on Cane Creek, five miles east of Coosa River, opposite

the Ten Islands, fifteen miles south of west from Jacksonville, and seven miles west of Alexandria, was built in 1843, rebuilt in 1857, 7 feet across the bosh by 32 feet high, and made in about thirty weeks of 1856 about 350 tons of foundry metal out of brown hematite ore from Chalybeate Springs bank two miles distant to the north and six other openings near the same.

254. **Shelby Steam Hot-blast Charcoal Furnace,** owned by Horace Ware of Columbiana, and leased by Clabaugh and Poole, is situated seven miles west of Coosa River, five miles south of Columbiana Railroad Station, seventeen miles east of Montevallo, sixty-two miles north of Montgomery, fifty-five miles north of Wetumpka, on the line of one of the contemplated routes for the Alabama Central railroad. It was built in 1849, rebuilt in 1855, 8 feet across the bosh by 29 feet high and made in thirty-five weeks of 1856 965¼ tons of foundry metal out of fibrous brown hematite ore from a ridge one mile long by half a mile wide at present opened three hundred yards to the north of the furnace.

255. **Russellville Charcoal Furnace,** in Franklin county Alabama, was built about 1818, abandoned about 1827, and is all in ruins.

256. **Independence Charcoal Furnace,** owned by the Carters of Elizabethton, stands one and a half miles above Ward's Forge, on Vaught's Creek, in Johnson county Tennessee, and was abandoned between 1845 and '47.

257. **Amanda Charcoal Furnace,** situated in Sullivan county Tennessee, on Little Sinking Creek, a half mile above Franklin Furnace, was built in 1837 by Geo. Bushong who tore it down after the first blast, and built Franklin.

258. **Franklin Cold-blast Charcoal Furnace,** owned by William Bushong, Holston Valley P.O. Sullivan county Tennessee, stands on Big Sinking Creek, twelve miles northwest of Elizabethton, two miles southwest of Papersville and four and a half miles southeast of Bristol; was built in 1838, is 8 feet across the bosh by 33 feet high, and makes about 150 tons of metal per annum out of hematite ore from Sharp's and Crockett's banks four or five miles north.

259. **Holston or Welcher's Cold-blast Charcoal Furnace,** owned by Welcher and Patton, managed by S. K. N. and J. A. Patton, and situated in Sullivan county Tennessee, six miles south of the Bristol Railroad station, was built in 1838, is 8½ feet across the bosh by 32 feet high, and made in twenty-three weeks

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of 1856 232 tons of metal out of hematite ore from Sharp's bank six miles and Crockett's bank three and a half miles distant to the northeast.

260. 261. Two old Furnaces on Beaver Creek close to Beaver Creek Forge in Sullivan county Tennessee, were abandoned in 1837, and only the stacks remain.

262. Union Cold-blast Charcoal Furnace, owned by Carter & Co. Elizabeth P.O. Carter county Tennessee, is so called from the union of Evelina and Ærial Furnaces, on Stony Creek, five miles above its junction with Watauga River, and eight miles east-northeast of Elizabethtown, which is six miles southeast of the junction of Doe and Watauga Rivers. It was built in 1847, and rebuilt 1855, 8 feet across the bosh by 30 high, and in the three years previous to 1857 has made an average of 17 tons of metal per week during about twenty weeks of each year, using brown hematite ore from Grindstaff and Hodge banks a half mile southeast and four miles east, mixed with red fossil ore from Canaan bank a mile to the northwest.

263. Evelina Charcoal Furnace, in Carter county, on a small branch, one quarter of a mile southeast of Union Furnace, was built in 1835, and torn down in 1847.

264. Aerial Charcoal Furnace, in Carter county, on a small branch, one and a half miles west of Union Furnace, was built in 1818, and torn down in 1847.

265. O'Brien's Charcoal Furnace, in Carter county, on Doe River, five miles east of Elizabethton, was built in 1836, and after two years' trial abandoned to ruin.

266. White's Charcoal Furnace, eighteen miles southwest of Elizabethton, in Carter county, Tennessee, was built about 1810 and abandoned sometime between 1845 and '47.

267. Little Troublesome Furnace, in Carter county, was built in 1839, and abandoned about 1842.

268. Rockbridge Charcoal Furnace, owned by the Carters of Elizabethton, stands on Little Stony Creek, two miles north of Farm Hall Forge, was built about 1840, abandoned in 1845, and is now a ruin.

269. Pleasant Valley Cold-blast Charcoal Furnace, owned by Robert L. Blair, Brothers and others, Cox's Store P.O. Washington county Tennessee, managed by John L. Blair, and situated opposite the Tennessee and Virginia railroad on the Molichucky River, in south side of the main Tennessee Valley and eight miles southwest of Jonesborough, is 8 feet across the

bosh by 28 feet high and made in about seventeen weeks of 1856 about 220 tons of metal out of hematite ore from a bank two and a half miles west of south.

270. **Clark's Creek Charcoal Furnace,** owned by Robert L. Blair and others, within four miles of Pleasant Valley Furnace, has never been used by its proprietors, is dilapidated, but a good stack remains.

271. **Bright Hope Charcoal Furnace,** originally owned by John Shields, is situated about eighteen miles west of Cleek's Forge, in Greene county Tennessee, was built about 1807, and ruined by a flood previous to 1837. A cupola furnace still in use marks the spot.

272. **Legion Charcoal Furnace,** on the head waters of Meadow Creek, about twelve miles northwest from Paint Rock, twelve miles east of Newport, and in Cocke county, was built about 1807, and abandoned about 1827.

273. **Love's Charcoal Furnace,** owned by And. Smith & Co, on the Little East Fork of Little Pigeon, sixteen miles east of Sevierville, and in Sevier county, Tennessee, was built probably about 1837 by Wm. and Jos. Love, and abandoned about 1852 to ruin.

274. **Ball Play Cold-blast Charcoal Furnace,** owned by Glenn and Hall, Ball Play P.O. Monroe county, Tennessee, on Ball Play Creek, twelve miles east of Madisonville, ten miles northeast of Tellico Furnace, and twenty-eight miles west of south from Amerine Forge, was built in 1851, $7\frac{1}{3}$ feet across the bosh by 32 feet high, and made in about eight weeks of 1854 about 135 tons of metal out of brown hematite ore from a bank one mile west in the butt of the Harland Mountain. It has made nothing since.

275. **Tellico Hot-blast Charcoal Furnace,** owned by the Tellico Manufacturing Company, Elisha Johnson, president and manager, Tellico Plains P.O. Monroe county, Tennessee, stands on Tellico River at the upper end of the plains, twelve miles southeast of Madisonville, ten miles southwest of Ball Play Furnace, thirty miles north of Ducktown twenty-two miles southeast of Athens, the nearest railroad station. It was built in 1840, is 9 feet across the bosh by 35 feet high, and made during thirty-nine weeks of 1855 about 550 tons of metal out of brown hematite ore from twelve banks, the principal one two miles southwest, and the rest between it and the stack, and has made nothing since 1856.

276. **Cumberland Gap Cold-blast Charcoal Furnace,** owned by Geo. G. Newlee, and managed by Hiram Holler,

Cumberland Gap P.O. Claiborne county Tennessee, is situated at the extreme southwestern point of Virginia, 116 miles west of Abingdon, 60 miles north-northeast of Knoxville, in the main pass of the Cumberland Mountains, five miles north of Powell's River, a branch of Clinch River, and twelve miles north of Tazewell, is 10 feet across the bosh by 28 feet high, and makes 150 tons of metal per annum out of fossil ore from an opening five hundred yards off.

277. Belleville Cold-blast Charcoal Furnace, owned by Reuben Rose of Tazewell, and Geo. W. Rose, Cumberland Gap P.O. on Indian Creek, twelve miles northeast of Tazewell, five east of Cumberland Gap, thirty west of Jonesville, and one mile south of State line, was built in 1828, is 9 feet across the bosh by 32 feet high, stood idle from 1853 till 1857, when it made in fourteen weeks about 400 tons of metal out of dyestone or red fossiliferous ore Formation V. from openings four miles off to the east and to the west-northwest.

278. Speedwell Charcoal Furnace, situated twelve miles northeast of Jacksborough, in Campbell county, Tennessee, was built about 1815, after Speedwell Forge, and was abandoned about 1830.

279. Sharp's Charcoal Furnace, in Granger county Tennessee, was abandoned about the year 1845.

280. Miller's Hot-blast Charcoal Furnace, owned by Lewis Miller and W. Longmire, Loy's Cross Roads P.O. Union county Tennessee, and situated on Buffalo Creek, nine and a half miles west of Maynardsville and half a mile southeast of Loy's Cross Roads, was built about 1837, is 7 feet across the bosh by 29 feet high, and made in two weeks of 1856 but 12 tons of metal out of dyestone (fossil) ore from openings to the east and south.

281. Eagle Steam and Water Hot-blast Charcoal Furnace, No. 1, owned by the East Tennessee Iron Manufacturing Company, R. Cravens agent, and situated on White's Creek, sixteen miles west of Kingston, two miles north of its mouth opposite Jackson Ferry and White's Creek shoals, thirty miles west of Loudon, twenty-two miles west of Sweet Water the nearest railroad station. Sixty miles by steamboat from the Nashville railroad at Chattanooga with Memphis connections, was built in 1839, is 8 feet across the bosh by 33 feet high, and made in 1854 about 450 tons of metal (one-fourth foundry) out of dyestone or red fossil (Clinton, Upper Silurian, No. V.) ore

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outcropping along the south side of the Tennessee River Stone-coal caps the mountain two miles off. Added its steam power lately.

282. **Eagle Cold-blast Charcoal Furnace,** No. 2, owned by R. Craven of Chattanooga, Hamilton county Tennessee, stands on White's Creek, in Roane county, close to Eagle No. 1, was built by R. Cravens, in 1844, of brick, for an experiment, stood about a year, and ran five or six weeks; is 4 feet across the bosh by 20 feet high, made from one to one and a quarter tons of very poor iron per day, and has been since abandoned.

283. **Piney Grove Charcoal Furnace,** in Roane county, on White's Creek, close by Turnpike Forge, 3 miles northwest of Eagle Furnace. Built 1823, abandoned 1828.

284. **Bluff Steam Hot-blast Charcoal Furnace,** owned by the East Tennessee Iron Manufacturing Company, R. Cravens agent, Chattanooga, stands in Chattanooga, on the Tennessee River, under the bluff, three-quarters of a mile north from the railroad station and thirty-eight miles by railway northwest of Dalton; was built in 1854, 10½ feet across the bosh by 40 feet high, but made nothing until 1856 in about thirteen weeks of which year were made about 172 tons of metal out of fossil dyestone ore from Jackson's bank sixty miles up the river, near the dividing line between Roane and Meigs counties, three miles south of Eagle Furnace. The bituminous coal of the Raccoon Mines, now leased and worked by the Etna Mining Company, can be brought to furnace by railway; it is excellent for coke, and some thoughts are entertained of turning the present furnace into a coke furnace.

285. **Lena Steam Hot-blast Coke Furnace,** owned by J. F. Penniman, of Union Square, New York, T. J. McKay, agent, Cumberland P.O. Alleghany county, Maryland, stands on the line of the Mount Savage Railroad, a half mile northwest of Cumberland, was built in 1846, 8 feet across the bosh by 28 feet high, and has stood idle seven years.

286. 287. 288. **Mount Savage Steam Hot-blast Coke Furnaces,** Nos. 1, 2 and 3, owned by the Mountain Savage Iron Company, and managed by Joseph Purser, Cumberland P.O. Alleghany county Maryland, are situated nine miles northwest of Cumberland, in the midst of the Frostburg Coal Basin, and are connected with the Baltimore and Ohio Railroad at Cumberland by a branch road eleven miles long. No. 1 was built in 1840, is 15 feet across the bosh by 50 feet high, and made in forty-four weeks of 1856 4,528 tons of metal for rail-

road purposes. No. 2 was built in 1840, is 15 feet across the bosh by 50 feet high, and made in forty-six weeks of 1854 about 4,500 tons of metal, since which it has stood idle. No. 3 was commenced in 1845, 52 feet high and has never been lined. These furnaces were built to use the Carbonate ores of the Frostburg coal basin, but did use chiefly the red fossil Upper Silurian ores of Formation V. near Cumberland mixed with some ores of middle Maryland.

289. Lonaconing Steam Hot-blast Coke Furnace, owned by the George's Creek Coal and Iron Company Dr. J. C. Atkinson superintendent, Lonaconing P.O. Alleghany county Maryland, is situated a quarter of a mile below Lonaconing Station on the Baltimore and Ohio Railroad, and bears date 1837, although there was an older charcoal furnace on the site. It is 15 feet across the bosh by 50 high and made in 1855 1,860 tons of iron from local ball and bog ores belonging to the Coal measures.

290. Virginia Cold-blast Charcoal Furnace, owned by Harrison, Hagans & Co. and managed by Wm. Hagans, Brandonville P.O. Preston county Virginia, stands one mile south of Brandonville and six east of north of Kingwood, was built in 1854, 11 feet across the bosh by 36 feet high, and has made but little iron, averaging twenty-five tons per week of chiefly forge metal out of limestone carbonate ore mixed with bone ore and some little fossil ore from the opposite side of the creek.

291. Old Valley Charcoal Furnace, owned by William Douglass, stands in ruins eight miles north of west from Brandonville, three miles north of Greenville Furnace, since 1840.

292. Greenville Cold-blast Charcoal Furnace, owned by H. and E. M. Hagans, stands in good repair six miles west of Brandonville and fifteen north-northwest of Virginia Furnace, but has made nothing since 1847, being built in 1840. It is probably abandoned.

293. Davis Cold-blast Charcoal Furnace, situated in Monongalia county, Virginia, one mile northwest of Henry Clay Furnace, has not been in blast for twenty-six years, and is in ruins.

294. Henry Clay Charcoal Furnace, owned by the Laurel Iron Company, Duncan J. Perry, manager, Pridevale P.O. Monongalia county, Virginia, stands in bad repair without machinery on Tom Quarry Run, four miles southeast of Pridevale and on the Pridevale Iron Company's lands, three miles from the river,

and connected with the forge and rolling mill by a railroad of an easy grade. It has not been in blast for a dozen years.

295. **Woodgrove Steam and Water Hot-blast Charcoal Furnace,** owned by the Laurel Iron company, and managed by Duncan J. Perry, Pridevale P.O. Monongalia county, Virginia, stands three miles east of Pridevale, on the road to Uniontown and within two miles of the State line; was built about 1826 by Mr. Jackson, and rebuilt in 1842, 7 feet across the bosh by 38 feet high, and made in about nine weeks of 1856 about 100 tons of metal out of blue lump carbonate ore from three miles northeast in the coal measures.

296. **Anna** (once Mars) **Steam Hot-blast Charcoal Furnace,** owned and managed by the same as Woodgrove, and standing on the right bank of Cheat River in the village of Pridevale, and on the Pridevale Company's lands, was built by Ellicott of Baltimore in 1847 and changed its name in 1853; is 10 feet across the bosh by 35 feet high, ran a few weeks in 1854 with coke and in fifteen weeks of 1856 made 396¼ tons of metal out of Marten bank ore a crop hematite of the coal measures, three miles off southeast.

297. **Valley Cold-blast Charcoal Furnace,** owned by James Kingsley, and managed by John Kingsley, Morgantown, P.O. Monongalia county Virginia, on Decker's Creek, four miles from Morgantown, five miles from Pridevale Ferry, was built about 1800, rebuilt in 1831, 8 feet across the bosh by 34 feet high, and made in 1856 perhaps 400 tons of railroad iron out of ore-banks within the circuit of a mile.

298. **Clinton Steam Cold-blast Charcoal and Coke Furnace,** owned by George Hardman, managed by Barney Newman, Clinton Furnace P.O. Monongalia county Virginia, and situated on Bull's Creek nine miles south of Morgantown, four miles south of Smithtown, and fourteen north of Independence, was built in 1847 and enlarged in 1855, to 8½ feet across the bosh by 32 feet high, and made in fifteen weeks of 1856 321¼ tons of charcoal forge and coke foundry metal out of crop hematite Reed ore from the coal measures two and a half miles north.

299. Piney Steam Cold-blast Charcoal Furnace, owned by R. and W. Miller, managed by J. P. Thoburn, Wheeling Virginia, and situated in Marion county Virginia, on Piney Run, five miles east of Fairmount, and two and a half miles from Winfield, was built probably about 1851, 8½ feet across the bosh by 32 feet high, and made in thirty-seven weeks of 1856 800 tons of metal out of coal measure hematite crop ore from half a mile north and south. Not in blast since the beginning of 1856 and tunnel head gone.

300. West Fork Cold-blast Charcoal Furnace, owned by Squire Brice of Fairmount, stands in good order but abandoned in Marion county Virginia, six miles from Fairmount. It has not run for twenty years. Another furnace, in Marion county, 8 miles east of Fairmount, and 8 miles west of Fetterman, on Tygart River, was in the way of the railroad, and therefore torn down.

301. Lancaster Steam Cold-blast Charcoal Furnace owned by Umbles & Dickinson, of Gap, Lancaster county Pennsylvania, managed by A. Willis, of Raccoon, Preston county Virginia, and situated in Taylor county Virginia, three miles west of Independence, was built in October 1856, 8 feet across the bosh by 33 feet high, and uses limestone carbonate ore from the coal measures three-quarters of a mile east, mixed with crop hematite ore of the same from six miles north.

302. Clarksburg Cold-blast Charcoal Furnace, No. 1, owned by the late Judge Jackson of Clarksburg, one mile east of Clarksburg, Harrison county Virginia, was destroyed about 1847.

303. Clarksburg Cold-blast Charcoal Furnace, No. 2, owned by the late Col. Ben. Wilson of Clarksburg, one mile west of Clarksburg, Harrison county Virginia, was torn down about 1846.

304. Valley (once Fanny) **Steam Cold-blast Charcoal Furnace**, owned by William Whitman of Baltimore, and managed by Jacob Baker, Jr. Nestorville P.O. Barbour county Virginia, stands on Breshet Fork of Tieter's Creek, two miles above the forks, sixteen south of Independence, and fifteen miles southeast of Thornton, and was built about 1845, 8 feet across the bosh by 32 feet high, and made in about twenty-two weeks of 1855, about 400 tons of metal out of blue lump carbonate ore of the coal measures mixed with crop or bog hematite.

305. Spring Hill Steam Hot-blast Charcoal Furnace, owned by Oliphant & Wilson, leased by F. H. Oliphant, man-

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aged by J. K. Duncan, Smithfield P.O. Fayette county Pennsylvania, and situated twelve and a half miles southwest from Uniontown, three east of north from N. Geneva on the Morgantown pike and three miles from Cheat River, is the fourth stack on the old site. The first was built in 1805, the third in 1830, and this in 1854, 9 feet across the bosh by 35 feet high, and made in twenty-eight weeks of 1856 246 tons of metal out of a poor hematite ore from the Snake Den, one hundred yards east, mixed with "point ore" from the mountain one mile east.

306. Fairchance Steam Cold-blast Furnace (and *Rolling Mill* see Table G No. 147), owned by F. H. Oliphant Uniontown P.O. Fayette county Pennsylvania, stands six miles south of Uniontown on the head waters of George's Creek, which enters the Monongahela River at N. Geneva, ninety miles above Pittsburg, was built in 1796, is 9 feet across the bosh by 35 feet high, and made in twelve weeks of 1856 about 600 tons of forge metal out of carbonitic ore from the west bank of Chestnut Ridge, six miles south of Uniontown.

307. Union Steam Hot-blast Charcoal Furnace, owned by Baldwin & Cheney, managed by Charles Cheney, Connelsville P.O. Fayette county Pennsylvania, and standing on Dunbar Creek, four miles southeast of Connelsville, in Dunbar Gap, was built in 1796, is 9 feet across the bosh by 32 feet high, and made in thirty-three weeks of 1856 964 tons of metal out of carbonitic ores of the coal measures from mines all around.

308. Coolspring Cold-blast Charcoal Furnace, owned by Wylie and Robinson, Uniontown P.O. Fayette county Pennsylvania, to the south of Uniontown, was built in 1820, is 7 feet across the bosh by 33 feet high, and has been abandoned since 1850.

309. Wharton Steam and Water Cold-blast Charcoal Furnace, owned by A. Stewart in 1849, to the south of Uniontown, Fayette county Pennsylvania, was built in 1835, is 8 feet across the bosh by 33 feet high, and has not run for years.

310. Red Stone Cold-blast Charcoal Furnace, owned by Worthington & Snyder, Uniontown, Fayette county Pennsylvania, on Redstone Creek, two miles east from Uniontown, was built in 1800, was formerly owned by Judge Huston, is 8 feet across the bosh by 30 high, and made in 1855 550 tons of metal out of carbonite ore of the coal measures.

311. **Mary Ann Cold-blast Charcoal Furnace**, in Greene county Pennsylvania, thirty miles from Uniontown, was the first furnace built by Mr. Oliphant, Sr., about 1777, and is now abandoned.

312. **Fairfield (Fairchance) Cold-blast Charcoal Furnace**, owned by F. H. Oliphant, stands seven miles south from Uniontown, was built in 1794 and is now abandoned.

313. **Pine Grove Cold-blast Charcoal Furnace**, owned by Basil Brownfield, stands eleven miles from Uniontown, and in Fayette county Pennsylvania, was built in 1805* and is now abandoned.

314. **Mt. Vernon Cold-blast Charcoal Furnace**, owned by George E. Hogg, on Jacob's Creek, in Fayette county Pennsylvania, eight miles north of Connelsville, and nineteen miles from Uniontown, was built in 1805* and is now abandoned.

315. **Fairview Cold-blast Charcoal Furnace**, owned by Joseph Victor, in Fayette county Pennsylvania, nine miles from Uniontown, was built in 1810* and is now abandoned.

316. **Mt. Hope Cold-blast Charcoal Furnace**, in Fayette county Pennsylvania, twenty-five miles from Uniontown, was built in 1810* and is now abandoned.

317. **Mt. Etna Cold-blast Charcoal Furnace**, owned by Davidson & Cummings, on the north bank of the Youghiogheny River, in Fayette county Pennsylvania, one and a half miles above Connelsville and twelve miles northeast from Uniontown, was built in 1810* and is now abandoned.

318. **St. John's Cold-blast Charcoal Furnace**, owned by Joseph Paull, in Fayette county Pennsylvania, eight miles from Connelsville, was built in 1815* and is now abandoned.

319. **Centre Cold-blast Charcoal Furnace**, owned by Ewing & Woods, three miles up Dunbar Creek, six miles from Uniontown, in Fayette county Pennsylvania, was built in 1815* and is now abandoned.

320. **Fayette Cold-blast Charcoal Furnace**, owned by J. Rogers, twelve miles from Uniontown, was built in 1815* and is now abandoned.

321. **Little Falls Cold-blast Charcoal Furnace**, owned by Miltonberger's executors, twelve miles from Uniontown, was built in 1815,* and is abandoned.

322. **Old Laurel Cold-blast Charcoal Furnace**, owned by James Paull's administrators, and situated in Fayette county Pennsylvania, three miles up Dunbar Creek, above old Union Furnace, and fifteen miles east of north from Uniontown, was built in 1820* and is now abandoned.

323. **New Laurel Cold-blast Charcoal Furnace**, owned by William Walker and standing fifteen miles east-northeast from Uniontown, was built in 1835,* and is abandoned.

324. **Breakneck Cold-blast Charcoal Furnace**, owned by John Fuller, and situated on Mount's Creek, in Fayette county Pennsylvania, fifteen miles northeast from Uniontown, four miles northeast of Connelsville, was built in 1826 and is now abandoned.

325. **Somerset Coal-blast Charcoal Furnace**, owned by

* About.

Hanna and Dyer, stands on the Somerset and Johnstown Pike, fifteen miles north of Somerset and twelve southwest of Johnstown was built in 1847, is 8½ feet across the bosh by 32 feet high, made no metal from 1848 or '49 until the spring of 1856, in eighteen weeks of which year were produced 247 tons out of hematite and fossil carbonate ore from two drifts one hundred feet over the tunnel-head, and a third a quarter mile up the left side of a branch of Ben's Creek.

326. **Shade Cold-blast Charcoal Furnace,** owned by Daniel Wyand, Stoystown P.O. Somerset county Pennsylvania, and situated sixteen miles south of Johnstown, was built in 1812, is 9 feet across the bosh by 30 feet high, and made in 1855 about 400 tons of metal and is since abandoned.

327. **Wellersburg Steam Hot-blast Charcoal Furnace,** owned by the Union Coal and Iron Company, E. L. Parker of Baltimore, president, J. P. Agnew, director, Wellersburg, Somerset county Pennsylvania, and situated nine miles northwest of Cumberland, belongs with Mount Savage, Lena and Lonaconing—being at the upper end of the Frostburg Coal Basin, but inside the Pennsylvania line, on Jenning's Run, north fork, with a railroad branch to the Mount Savage Branch of the Baltimore and Ohio railroad. It was built in 1856, 14 feet across the bosh by 45 feet high, and made an experimental blast of 1,200 tons of metal out of coal measure carbonate ores mixed with some red fossil of V. and some brown hematite.

328. **Rockingham Cold-blast Charcoal Furnace,** owned by Henry Little (in 1855) Stoystown P.O. Somerset county Pennsylvania, situated in Somerset county, was built in 1844, 6 feet across the bosh by 21 feet high, and is abandoned.

329. **California Hot-blast Charcoal Furnace,** owned by Mathiot & Cummings, and managed by Moses Collins, Laughlintown, Westmoreland county Pennsylvania, is situated on the Philadelphia and Pittsburgh Turnpike, fifty-three miles east from the latter, at the foot of Laurel Hill, on Furnace-Run Branch of the Loyalhanna River, a mile above its mouth, and one mile south of Laughlintown, was built about 1852, 8 feet across the bosh by 31 feet high, and made in twenty-one weeks of 1856 334 tons of principally foundry iron out of coal measure carbonate ore from the Ligonier Coal Basin, the principal bank three-quarters of a mile to the north, and others to the east and south, mixed with some fossil ore.

330. **Washington Hot-blast Charcoal Furnace,** owned by L. C. Hall, Ligonier P.O. Westmoreland county Pennsylvania, is situated on the turnpike east of Ligonier village, towards Stoystown, at the base of Laurel Hill, was built in 1809, 9 feet across the bosh by 35 feet high, but is abandoned for the present, and if used again will be rebuilt. About 700 tons in 1854 were made.

331. **Valley C Steam Hot-blast Coke Furnace,** owned by L. C. Hall & Co. and managed by L. C. Hall, Ligonier P.O. Westmoreland county Pennsylvania, stands four miles south of Ligonier in Ligonier Valley, three miles from the base of Laurel Hill and four from that of Chestnut Ridge, nine miles south of New Florence Station on Pennsylvania Railroad and Canal, was built in 1855, is 10 feet across the bosh by 40 feet high, and made in ten weeks of each of the years 1855 and 1856 500 tons of metal out of coal measure carbonate ball ore, *traced* three and a half miles nearly due north and four south, dipping gently both ways into the centre line of the basin—*opened* from the bridgehouse of the furnace each way for half a mile.

332. **Hermitage Coal-blast Charcoal Furnace** is situated in Westmoreland County Pennsylvania, two miles northeast of Ligonier, on the present Ligonier and Johnstown Turnpike, was abandoned many years ago, and is a ruin.

333. **Oak Grove Cold-blast Charcoal Furnace,** owned by Mr. James Tanner of Pittsburgh, is situated in Westmoreland county Pennsylvania, was built in 1854 by John Clifford, is 9 feet across the bosh by 33 feet high, and made an average of 500 tons of metal in the three years preceding 1857, when it blew out, in good order, but with no probability of its ever being started again.

334. **Ross Cold-blast Charcoal Furnace,** owned by George T. Paull, Smithfield P.O. Westmoreland county Pennsylvania, is situated four and a half miles south of New Florence Railroad Station, and in Fairfield Township, was built in 1815, is 8 feet across the bosh by 30 high, has not been in blast since 1850 and waits for a second growth of timber or for bituminous coal.

335. **Laurel Hill Hot-blast Charcoal Furnace,** owned by John Graff of Blairsville, and leased (1856) by E. Hoover, New Florence P.O. Westmoreland county Pennsylvania, is situated three miles east of New Florence Railroad Station; was built in 1846, is 9 feet across the bosh by 33 feet high and has been idle since 1855, in which year it made 750 tons of metal.

336. **Conemaugh Hot-blast Coke Furnace,** owned by the Johnstown Iron Company, J. Rhey, agent, Johnstown P.O. Cambria county, Pennsylvania, is situated three miles east of

New Florence Station in the Gap of Laurel Hill, on the Conemaugh River and Pennsylvania Railroad, seven and a half miles northwest of Johnstown; was built in 1847, is 10 feet across the bosh by 40 high, and made in twenty-one weeks of 1856 708½ tons of metal out of coal measure carbonate ore the same as used by the Johnstown Furnaces, mixed with a hematite crop ore from a bed recently explored.

337. **Ramsey Cold-blast Charcoal Furnace,** owned by Dr. Spear of Kiskiminetas (1849), stands four miles above Warren in Westmoreland county, was built in 1847 and has been abandoned.

338. **Lockport Cold-blast Charcoal Furnace,** owned by William McKinney of Lockport (1849) and situated at Lockport Westmoreland county Pennsylvania, was built in 1844 by William D. McKernan, tried several times, made little iron, and went out finally in the winter of 1846–7. Dr. Schonberger bought and repaired it just before his death. It is 8 feet across the bosh by 33 feet high, and finally abandoned.

339. **Buena Vista Cold-blast Charcoal Furnace,** owned by Dr. Alexander Johnson of Hollidaysburgh, Blair county Pennsylvania, is situated in Indiana county, four miles north of the Pennsylvania Railroad and Canal, and three miles east of Armaugh, was built in 1847, 8 feet across the bosh by 31 feet high, and made 560 tons of metal in 1854 out of shell and bog ore from the neighboring coal measures. Since 1856 it has stood idle.

340. **Indiana Hot-blast Charcoal and Coke Furnace,** owned by Elias Baker of Altoona, Blair county, Pennsylvania, and situated near Armaugh in Indiana county, five miles east of New Florence Station, was built in 1842, is 9 feet across the bosh by 30 feet high, and blew regularly during all of 1857, making 1,547 tons of metal out of hematite ore from Baker's Bank, four miles north of Altoona, Blair county.

341. **Black Lick Steam Hot-blast Charcoal Furnace,** owned by the Cambria Iron Works, Wood, Morrell & Co, lessees, and situated in Indiana county, Pennsylvania, twelve miles northeast from Johnstown, was built in 1846, is 8 feet across the bosh by 35 feet high, and made in thirty-five weeks of 1856 955 tons of metal.

342. **Loop Cold-blast Charcoal Furnace,** owned by T. White in 1855, now by Wade Hampton of Pittsburg, is situated in Indiana county Pennsylvania, three

miles below Smicksburg, on L. Mahoning, was built in 1847, is 9 feet across the bosh by 33 feet high, and is now abandoned.

343. Johnstown Steam Hot-blast Coke Furnace, owned by the Johnstown Iron Company (Rhey, Matthews & Co.) managed by J. King, Johnstown P.O. Pennsylvania, and situated in Cambria county, an eighth of a mile north of Johnstown Railroad Station, was built in 1846, is nearly 10 feet across the bosh by 40 high, and made in forty-five weeks of 1856 2,044½ tons of metal out of carbonate of iron with carbonate of lime enough to flux, from a gangway eighteen hundred and twenty feet distant.

344. Mill Creek Steam Hot-blast Coke Furnace, owned by the Cambria Iron Works, and leased by Wood, Morrell and Company, Johnstown P.O. Cambria county Pennsylvania, stands on Mill Creek, three and a half miles southwest of Johnstown Railroad Station, is 12 feet across the bosh by 40 high. Built in 1845 and rebuilt in 1856 it went into blast in April of that year, and made in the remaining thirty-five weeks 2,720 tons of metal, out of coal measure carbonate ore.

345. Ben's Creek Hot-blast Charcoal Furnace, owned and leased as the last, stands at the mouth of Ben's Creek, near the plank road crossing, three miles south of Johnstown Station; was built in 1846, 9 feet across the bosh by 35 feet high, and made in thirty-nine weeks of 1856 902 tons of metal, out of coal measure ore.

346. Old Cambria Steam Hot-blast Coke Furnace, owned and leased like the two last, on Laurel Run, three-quarters of a mile from the Pennsylvania Canal, three miles north of Johnstown Station, was built in 1842, rebuilt in 1854, 9½ feet across the bosh by 38 feet high, and made in fifty weeks of 1856 2,225 tons of metal out of carbonate and fossil ores. Here Kelly's process has just been tried with great success.

347. 348. 349. 350. Cambria Steam Hot-blast Coke Furnaces, owned and leased by the same parties as the three last named furnaces, all stand on the Johnstown flat, one quarter of a mile north of the Johnstown Railroad Station, and a little north of the great Cambria Rolling Mill. They are all of one size, 13 by 48, although built at different times, No 1 in 1854,

rebuilt when No. 2 was built in 1854, No. 3 in 1856 and No. 4 in 1857 but never finished. One engine blows all three. No. 1 made in 1855 6,543 tons, No. 2 and 3 in 1856 6,547 and 5,996 tons of mill metal out of coal measure carbonate of iron ore mined in nearly horizontal layers in the hills behind the furnaces.

351. **Eliza Hot-blast Charcoal Furnace,** owned by Alter and others of Phila delphia, in Cambria county Pennsylvania, about four miles above Black Lick Furnace, was built in 1846, 9 feet across the bosh by 30 high, and was abandoned in 1848.

352. **Ashland Charcoal Furnace,** owned in 1849 by Hugh McNeil, Summit P.O. on Clearfield Creek, Cambria county Pennsylvania, six miles north of Galitzen station, was built in 1847 8 feet across the bosh by 33 feet high, and abandoned in 1851.

353. **Farrandsville Hot-blast Coke Furnace,** owned by Fallon and others of Philadelphia, situated in Clinton county Pennsylvania, six miles north of Lock Haven, was built in 1834 10×45, of cut stone and at great expense, with apparatus and surroundings on the same scale, in confident expectation of smelting coal measure ores with semi-bituminous coal or coke, and at least half a million of dollars were expended before proper experiments had tested the quality of the coal and ore beds. In the end the whole was abandoned about 1838.

354. **Astonville Hot-blast Charcoal and Anthracite* Furnace,** owned by William Thompson, Ralston P.O. Lycoming county Pennsylvania, stands near the village of Ralston, and near the Williamsport and Elmira Railroad and Lycoming Creek, was built for charcoal in 1855, 10 feet across the bosh by 37 feet high, and only made 7 weeks blast on anthracite. It will produce 12 tons per day with Ralston (No. XI.) ore; and may have produced in 1856 700 tons charcoal iron, and in 1857 100 tons of anthracite iron.

355. **Ralston Hot-blast Charcoal and Anthracite* Furnace,** owned by the Lycoming Iron and Coal company, managed by J. D. Mitchell, Ralston P.O. Lycoming county Pennsylvania, and situated in the village of Ralston, on the Williamsport and Elmira Railroad and Lycoming Creek; was erected in 1854 in the place of the old furnace burnt down in 1853–54. It is 16 feet across the bosh by 45 feet high, and can produce 20 tons a day with anthracite and Ralston ore. It made say 75 tons in 1856. There are 2 beds of coal on the top of the mountain back of the furnace. A railroad ascends to the mines. After two unsuccessful blasts the furnace was abandoned. The ore is a carbonate of iron in solid layers and in balls, underlying the bottom conglomerate of the coal measures.

* Not noticed in Anthracite Table.

356. **Carterville Steam Hot-blast Charcoal Furnace,** owned by Carter and Company, Ralston P.O. Lycoming county Pennsylvania, situated south of Ralston, was built in 1854, 10 feet across the bosh by 35 high, and is abandoned.

357. **Mansfield Steam Hot-blast Charcoal Furnace,** owned by the Mansfield Iron Company, Mansfield P.O. Tioga county Pennsylvania, on the west bank of the Tioga River, opposite the village of Mansfield, and ten miles north of Blossburg, was built in 1854, 10 feet across the bosh by 33 feet high, and made in twenty-one weeks of 1856 about 600 tons of metal out of a peculiar fossiliferous ore from three miles west, on the rolling country of Formation VIII. three or four hundred feet above the river on the road to Wellsborough.

358. **Blossburg Hot-blast Charcoal Furnace,** owned by James H. Gulick, Blossburg P.O. Pennsylvania, in the town of Blossburg, Tioga county, was built in 1841, 7½ feet across the bosh by 21 feet high, and is so much out of repair that it will probably be no more used. There is a rolling mill attached.

359. **Rock Steam Cold-blast Charcoal Furnace,** owned by T. A. Scott, Altoona, Pennsylvania, stands on Roaring Run, in Apollo Township, Armstrong county Pennsylvania, four miles east of Warren; was built in 1847, 8 feet across the bosh by 30 feet high, and made about 100 tons in 1855, and nothing since.

360. **Winfield Steam Hot-blast Charcoal and Coke Furnace,** owned by the Winfield Coal and Iron Company, and managed by D. R. Smith, Slate Lick P.O. Armstrong county Pennsylvania, and situated on Rough Run, eight miles west of north from Freeport, in Butler county fourteen miles southeast of Butler, was built in 1848, 9 feet across the bosh by 37 feet high, and made in twenty-four weeks of 1856 about 1,400 tons of mostly foundry metal out of soft hematized outcrop coal measure carbonate ore found in a layer two feet thick.

361 **Buffalo Steam Hot-blast Charcoal Furnace,** No. 1, owned by P. Gruff & Co. and managed by Joseph C. King, Kittanning P.O. Armstrong county, Pennsylvania, on Buffalo Creek, at the Kittanning and Butler Pike crossing, six miles west of Kittanning, forty north of Pittsburg, and fourteen east of Butler; was built in 1846, 8 feet across the bosh by 35 feet high, and made in about thirty-nine weeks of 1855 1,719 tons of forge and foundry metal out of the same kind of ore as at Brady's Bend.

362. **Buffalo Steam Hot-blast Charcoal Furnace,** No. 2, owned, managed, and situated as No. 1, was built in 1839, is

9 feet across the bosh by 36 feet high, and made in forty-six weeks of 1856 2,081 tons of metal.

363. **Cowanshannock Cold-blast Charcoal Furnace,** owned by James E. Brown, Kittanning P.O. Armstrong county Pennsylvania, is situated three miles north of Kittanning, and one mile up Cowanshannock Creek, was built in 1845, 8 feet across the bosh, and abandoned in 1851.

364. **Pine Creek Steam Hot-blast Charcoal Furnace,** owned by Brown and Mosgrove, managed by James Mosgrove, Kittanning P.O. Armstrong county Pennsylvania, and situated in Valley (formerly Pine) township, on Pine Creek, six miles east of Kittanning, was built in 1846, 10 feet across the bosh by 32 feet high and made in twenty-six weeks of 1856 1,295 tons of forge metal out of fossil limestone ore from beds in the coal measures four miles round, the principal openings being within four hundred yards.

365. **Ore Hill Steam Hot-blast Charcoal Furnace,** owned by William McCutcheon, and managed by Jesse Bell, Kittanning P.O., Armstrong county Pennsylvania, on the Alleghany River, eight miles east of north from Kittanning and on the Olean road was built in 1845, and blew out in the spring of 1857 for want of wood. It is 8½ feet across the bosh by 34 feet high, and made in forty-one weeks of 1856 1,525 tons of mottle iron, out of limestone carbonate ore, from two miles above the furnace on each side of the river, and on each side of Whisky Hollow.

366. **America Steam Hot-blast Charcoal Furnace,** owned by John Jamieson, James Knight, Kittanning P.O., Armstrong county Pennsylvania, on the Alleghany River, ten miles northwest of Kittanning, was built in 1846, 8 feet across the bosh by 28 feet high, and made in forty-one weeks of 1856 1,600 tons of forge metal out of fossiliferous limestone ore, outcropping horizontally among the coal measures in all directions around the furnace, within three miles.

367. **Alleghany Hot-blast Charcoal Furnace,** owned by A. McMickle in 1850, situated in Armstrong county Pennsylvania, to the north of Kittanning, was built in 1830 and abandoned before 1850.

368. **Stewardson Steam Hot-blast Charcoal and Coke Furnace,** owned by Alex. Laughlin and managed by Joseph Steele & R. B. Laughlin, Kittanning P.O. Armstrong county Pennsylvania, stands on Mahoning Creek one and a half miles from the Alleghany River and eleven northeast from Kittanning. Built in 1851 (for coke, but not very successful) it is 11½ feet across the bosh by 40 feet high, made in thirty-two weeks

of 1856 1,147 tons of metal, 120 tons of which were by coke, out of limestone carbonate ore from the coal measures two miles around.

369. Mahoning Steam Cold-blast Charcoal Furnace, owned by J. A. Caldwell & Co. Kittanning P.O. Armstrong county Pennsylvania, stands on the Mahoning Creek ten miles above its mouth and fifteen northeast of Kittanning. Built in 1845, 10 feet across the bosh by 33 feet high, it made in forty-six weeks of 1856 1,796 tons of forge metal out of hard blue carbonate lying on a limestone bed in the coal measures one hundred feet above the water, within a mile.

370. Olney Hot and Cold-blast Charcoal Furnace, owned by John McCrea, and managed (1854, '55) by W. W. Corbet, Kittanning P.O. Armstrong county Pennsylvania, stands on Mahoning Creek, fourteen miles above its mouth and seventeen north of east from Kittanning. Built in 1847 and enlarged in 1855 to 9 feet across the bosh by 32 feet high, it has been out of blast three years and made in twenty-three weeks of 1855 568 tons of metal out of fossiliferous and hard limestone ore, from beds in the coal measures within three miles around.

371. Phœnix Cold-blast Charcoal Furnace, owned by Governor Johnson of Pittsburg, H. N. Lee, William Philips and James Laughlin, is situated on the north side of Mahoning Creek, in Armstrong county Pennsylvania, five miles above Olney Furnace. Built in 1846, 8 feet across the bosh by 30 high, it has been out of blast since 1853, but is in sufficiently good order to go into blast again. Its ore is a loamy outcrop of the lower (buhrstone) ore, dirty and soft, making the best of foundry iron.

372. 373. 374. 375. Brady's Bend Steam Hot-blast Charcoal Furnaces, Nos. 1, 2, 3 and 4, owned by M. P. Sawyer of Boston and others, Great Western Iron Works, Brady's Bend P.O. Armstrong county Pennsylvania, are situated on the Alleghany River, fifty-five miles by land and seventy by water above Pittsburgh. No. 1 was built in 1840, 14 feet across the bosh by 50 feet high, and made in the year 1856 5,391 tons of forge metal out of coal measure carbonate ore from mines one and a half miles south of the works. No. 2 was built in 1841, the same size and made in 1856 5,576 tons. No. 3 was built in 1843, is 11 by 43, and made in eighteen weeks of 1854 1,745 tons of metal, and ran only two weeks in 1856. No. 4 was built in 1846, is 11 by 43 also, and made in four weeks of 1855 218 tons forge metal.

376. Red Bank Steam Cold-blast Charcoal Furnace, owned by Reynolds and Richie in 1850, Red Bank P.O. Arm-

strong county Pennsylvania, stands on Red Bank Creek, was built in 1842, 9 feet in the bosh by 32 feet high and made in 1854 and '55 perhaps 2,000 tons.

377. Pike Steam Hot-blast Çharcoal Furnace, owned and managed by Hunter Orr, Clarion P.O. Clarion county Pennsylvania, stands on Fiddler's Run or Lowsonham Creek, half a mile from Red Bank Creek and five miles from the Alleghany River, nineteen miles from Clarion and sixty-two from Pittsburg. It was built in 1845, is 8 feet across the bosh by 30 high, and made in thirty-six weeks of 1856 1,012 tons of metal from limestone ore, soft brown and hard blue, in beds which crop out among the coal measures horizontally around the furnace.

378. Franklin (Old Wild Cat) Steam Cold-blast Charcoal Furnace, lately owned by John L. Miller of Pittsburg, is situated in Clarion county, one mile east of Pinksville (Remersburg), and seventeen miles north of Kittanning, was built in 1843, 7½ feet across the bosh by 28 feet high, and made in 1856 1,380 tons of metal and was abandoned in 1857.

379. St. Charles Steam Charcoal Furnace, owned and managed by Patrick Kerr, Clarion P.O. Clarion county Pennsylvania, on Leatherwood Creek, at the Olean Road Crossing, two and a half miles west of the Alleghany Valley Railroad location line, and twenty north of Kittanning, was built in 1844, is 10 feet across the bosh by 33 feet high, and made in fifty weeks of 1856 about 2,000 tons of forge metal out of limestone carbonate ore which outcrops among the coal measures on both sides of the creek valley.

380. Catfish Steam Cold-blast Charcoal Furnace, owned by Alex. Miller, leased by J. L. Miller, and managed by J. H. Kahl, Clarion P.O. Clarion county Pennsylvania, stands on the Alleghany River, three miles north of the Great Western Iron Works (Brady's Bend), at the mouth of Catfish Creek, on the Kittanning and Clarion Road, five miles south of Remersburg and west of Franklin Furnace. It was built in 1846, 8 feet across the bosh by 30 high, and made in thirty-three weeks of 1856 925½ tons of metal out of carbonate and bog ores from the coal measures within a mile to the north.

381. Black Fox Steam Hot-blast Charcoal Furnace, owned by Jacob Painter and others, and managed by S. Barr,

Clarion P.O. Clarion county Pennsylvania, stands on the Alleghany River, one mile above Miller's Eddy, six miles north of Brady's Bend, on the Brady's Bend—Clarion Road, twenty miles south of Clarion. It was built in 1844, 9 feet across the bosh by 30 high, and made in thirty-five weeks of 1856 1,353 tons of metal out of red limestone ore (buhrstone) from beds among the coal measures within five miles' hauling.

382. Maple Steam Charcoal Furnace, owned and managed by M. S. Adams, Butler P.O. Butler county Pennsylvania, on Little Bear Creek, four miles west of the Alleghany River, twelve north of Brady's Bend, on Brady's Bend—Franklin Road, was built in 1843, 8 feet across the bosh by 30 high, and made in twenty-four weeks of 1856 810 tons of metal out of coal measure carbonate ores from mines three miles south and east.

383. Dudley Steam Hot-blast Charcoal Furnace, owned by Crawford and Arnold of Kittanning, and managed by Robert Crawford, Kittanning P.O. Armstrong county Pennsylvania, is situated in Butler county, a half mile east of Martinsburg, two and a half west of Alleghany River, near Maple Furnace, and seven miles northwest of the Great Western Iron Works, was built in 1857, and fired up first on the fifteenth of December of that year.

384. Kensington Cold-blast Charcoal Furnace, owned by Lenier & Co. Bankers of New York, and situated in Butler county Pennsylvania, to the westward of the Great Western Iron Works, was built in 1847, 8 feet across the bosh by 30 high, and made about 1,100 tons of metal in the years 1854 and '55, and was then abandoned for want of ore.

385. Bear Creek Cold-blast Charcoal Furnace, in Butler county Pennsylvania, one mile back of Lawrenceburg, on the west side of the Alleghany River, above Brady's Bend, has been abandoned many years and is dilapidated.

386. Hickory Cold-blast Furnace, in Butler county Pennsylvania, on Slippery Rock Creek at the Falls, twenty-six miles south of Franklin, on the main road to Pittsburg, twenty east of Newcastle and two and a half miles north of the four corners of the Pittsburg—Erie and Pittsburg—Franklin pikes, was built in 1840, 8 feet across the bosh by 28 feet high, and made in twenty weeks of 1855 750 tons of chiefly foundry metal out of soft red fossiliferous limestone ore from a number of beds lying between coal measures within four miles around furnace.

387. Marion Cold-blast Charcoal Furnace, owned and managed by Case & Co. Harrisville, Butler county Pennsylvania, on the head waters of Slippery Rock Creek, four miles north of Harrisville, was built in 1848, 8 feet across the bosh by 32 feet high, and makes about 500 tons per annum out of the buhrstone ore of the Lower coal mines.

388. Stapley Steam Cold-blast Charcoal Furnace, owned and managed by R. and C. Shippen, Shippenville, Clarion county Pennsylvania, is situated four miles north of Emlenton and east of Glen (on the Alleghany River), and one and a half miles west of the road twelve miles south of Shippensville, was built in 1854, 8 feet across the bosh by 30 high, and makes regularly 1000 tons a year.

389. Richmond Steam Cold-blast Charcoal Furnace, owned and managed by John Keating, Clarion P.O. Clarion county Pennsylvania, on a run north of Clarion River and three miles east of Stapley Furnace, was built by the owner in 1846, 8 feet across the bosh by 30 high, and made in the three years preceding 1857 an average of about 550 tons of metal per annum out of coal measure ores.

390. Jefferson Steam Hot-blast Charcoal Furnace, owned by S. F. Plumer, and managed by John Haslett, Clarion P.O. Clarion county Pennsylvania, on Beaver Creek, three miles west of the Clarion River, eight miles east of the Alleghany River and fourteen west of Clarion, was built in 1838, has run irregularly and will be abandoned for want of timber, is 8 feet across the bosh by 33 feet high, and made in 1856 about 600 tons of forge metal out of fossil (limestone) and bog ores from the coal measures one hundred feet above the furnace on the hill side three miles to the south.

391. Prospect Steam Cold-blast Charcoal Furnace, owned by Moore, Painter & Co. and managed by Wm. Moore, Clarion P.O. Clarion county Pennsylvania, on Cherry Run, at the Callensburg—Catfish Furnace road crossing, one mile south of Callensburg, two miles south of Clarion River and six from the Alleghany River, was built in 1845, 8 feet across the bosh by 30 high, and made in thirty-nine and a quarter weeks of 1856 1,450 tons of mill iron out of blue coal measure limestone ore from many banks within three and a half miles round.

392. Eagle Cold-blast Charcoal Furnace, owned by Reynolds and Kribbs, and managed by George Kribbs, Clarion P.O. Clarion county Pennsylvania, is situated on Canoe Creek, one mile north from Clarion River, ten miles east of Alleghany River, eight miles south of Bellefont and Erie Pike, ten miles west of Clarion and sixty-five northeast of Pittsburg. It was built in 1846, 8 feet across the bosh by 30 high, and makes 700 or 800 tons per annum out of the soft brown hematite outcrop of the buhrstone ore of the lower coal measures.

393. Tippecanoe Steam and Water Cold-blast Charcoal Furnace, owned by King and Maxwell, situated in Clarion county Pennsylvania, on Canoe Creek, one mile above Eagle Furnace, was built in 1844 by Black & Maxwell, and run by the present owners until 1851, when it was abandoned.

394. Beaver Steam and Water Hot and Cold-blast Charcoal Furnace, owned by Long, Blackstone & Co. on Deer Point Creek, two and a fourth miles below Shippen Furnace and five miles south of Shippenville, was built in 1835 and abandoned in 1854. It was 9 feet across the bosh by 33 feet high, and had made as high as 1,500 tons in a year. The last blast was hot.

395. Buchanan Cold-blast Charcoal Furnace, owned by F. G. Crary of Kittanning Armstrong county, and standing, now dismantled (since April, 1856), four miles west of Sligo Furnace, No. 396, on the Clarion River near Callensburg, Clarion county Pennsylvania, was built in 1844, 8 by 30, and averaged 1,200 tons a year of iron out of coal measure ores. Its timber is exhausted.

396. Sligo Steam Cold-blast Charcoal Furnace, owned by Lyon, Shorb & Co. of Pittsburg, and situated on Licking Creek in Piney township, three miles southwest of Curlsville and ten miles south of Clarion county Pennsylvania, was built in 1845, is 9 feet wide across the bosh by 32 feet high, and made in forty-three weeks of 1856 1,998 tons of rolling mill iron out of argillaceous carbonate ores of the coal measures close by.

397. Madison Steam Cold-blast Charcoal Furnace, owned by Lyon, Shorb & Co. of Pittsburg, like the last, and situated on Piney Creek in Piney township, six miles southwest of Clarion Pennsylvania, was built in 1836, 9 feet wide across the bosh by 32 feet high, and made in forty-five weeks of 1856 2,140 tons of mill metal out of coal measure carbonate ores from mines three or four miles around.

398. Martha (Polk) Steam Cold-Blast Charcoal Furnace, owned by Lyon Shorb & Co. like the last, stands dismantled and abandoned, six miles south of Clarion, on the Kittanning-Clarion Road four miles north of Curlsville. It was

built in 1845 9 × 30, and made in 1854 1,260 tons out of the buhrstone ore of the Lower Coal measures. Its timber is exhausted.

399. Washington Steam Cold-blast Charcoal Furnace, five miles south of Clarion, owned by Lanier & Co. of New York city, stands on the northwest side of Piney Creek, one and a half mile east of the Kittanning road, built in 1846 8½ feet wide by 32 feet high inside, it stopped in the spring of 1855 having made 706 tons that year out of red limestone (buhrstone) hematite coal measure ore mined near by.

400. Monroe Cold-blast Charcoal Furnace, six miles south of Clarion, owned by W. B. Fetzer & Co. stands on Piney Creek in Clarion county Pennsylvania at the crossing of the Clarion-Greensville-Kittanning road, and was built in 1845 8 by 30 feet inside, and made in eighteen weeks of 1855 393½ tons of metal out of coal measure ores.

401. Limestone Cold-blast Charcoal Furnace, eight miles southeast of Clarion, owned by J. Painter and G. P. Smith, stands on Piney Creek in Clarion county Pennsylvania. It was built in 1845 8 feet wide across the bosh, and was abandoned in 1853.

402. Shippensville Hot-blast Charcoal Furnace, four miles west of Clarion, owned by Richard Shippen and Jacob Black, managed by Robert Montgomery of Shippensville, Clarion county Pennsylvania, stands on the forks of Deer and Paint Creeks, one mile south of Shippensville; was built in 1832 9 feet wide across the bosh by 32 feet high, and made in forty-three weeks of 1856 1,229 tons of mill metal out of buhrstone coal measure carbonate ores mined near the furnace.

403. Mary Ann Cold-blast Charcoal Furnace, three miles west of Clarion, owned by J. and A. Black and standing one mile east of Shippensville on Paint Creek at the Clarion and Franklin Pike crossing, was built in 1844, 8 feet across the bosh, and abandoned in 1851.

404. Deer-Creek Cold-blast Charcoal Furnace, four and a half miles west of Clarion, owned by Dr. Mease & Co. and situated half a mile west of Shippensville where the Clarion and Franklin Pike crosses Deer Creek, was built the same year, of the same size and abandoned at the same time as the last.

405. Elk Cold-blast Charcoal Furnace, five and a half miles west of Clarion, last leased by Kehl & Call, stands also on Deer Creek, one mile higher up than the last, was built in 1842, 7 by 22, and abandoned in the fall of 1855 for want of ore and fuel, having made about 400 tons per annum, out of buhrstone ore.

406. Clarion Cold-blast Charcoal Furnace, one and a quarter miles north west of Clarion, owned by Nelson Hetherington of Clarion, stands on the Clarion

River, was built in 1848 8 feet across the bosh by 30 high, and has been abandoned for want of ore, timber being abundant, since 1850.

407. Lucinda Hot-blast Charcoal Furnace, eight miles north of Clarion, owned by Buchanan & Reynolds, leased by Reynolds & Evans, managed by C. A. Rankin, Clarion county Pennsylvania, and situated on Paint Creek, was built in 1833, 8 feet across the bosh by 30 feet high and made in thirty-one weeks of 1856 995 tons of foundry metal, out of coal measure buhrstone ores mined within five miles all round. Timber is getting scarce, and the furnace will be abandoned this year.

408. Helen Cold-blast Charcoal Furnace, three miles east from the last, owned and managed by Samuel Wilson and David McKim, of Strattonville, Clarion county Pennsylvania, and situated between the Little Toby and the Clarion Rivers, eight miles due north from Clarion on the road to Scotchhill, was built in 1845 8 feet across the bosh by 32 feet high, and made in twenty-six weeks of 1856 756 tons of iron out of buhrstone coal measure ore, mined back of the tunnel head.

409. Corsica, formerly Mount Pleasant Steam Charcoal Furnace, seven miles east-northeast of Clarion, owned and managed by John P. Brown and situated on a run two miles north of Roseburg and half a mile southeast of the Clarion River, was built in 1847 8 feet wide across the bosh by 30 high and made about 500 tons per annum out of burhstone ore close by.

410. Forest Steam Hot-blast Charcoal Furnace in the northeast corner of Venango county, owned and managed by William Cross & Son, and situated on Little Hickory Run one mile east of the Alleghany River and six miles from the Tionista Post-office, was built in 1853 8 feet across the bosh by 32 feet high, and makes 450 tons per annum.

411. Licking Cold-blast Charcoal Furnace in Venango county ten miles north of Clarion and four miles west of Tylersburg, was built in 1845 7½ by 30 feet inside and abandoned in 1856. It used to make about 400 tons per annum.

412. Hemlock Steam Cold-blast Charcoal Furnace, in Venango county Pennsylvania, twelve miles northwest of Clarion and two of Freiburg or the old Cobb settlement, owned by F. and W. M. Faber of Pittsburg; was built by McGuire & Fetzer

in 1845 $7\frac{1}{2} \times 30$ inside and made in forty weeks of 1856 about 910 tons of metal, out of lower coal measure ores.

413. Clinton Steam Cold-blast Charcoal Furnace in Venango county fourteen miles northwest of Clarion, owned by S. F. Plumer of Franklin, managed by William Holliss and situated on Hemlock creek eight miles east of the Alleghany River, was built in 1841 9½ feet wide across the bosh by 33 feet high, and made in forty-three weeks of 1856 1,620 tons of forge metal, out of fossil buhrstone fossil limestone lower coal measure ore, mined two miles south of the furnace.

414. President Cold-blast Charcoal Furnace in Venango county sixteen miles northwest of Clarion, owned by Arnold Plumer of Franklin, and situated on Hemlock run between Cobb settlement and the Alleghany River. Built in 1847 8 feet across the bosh by 30 high and standing idle several years it began again in 1857 to make fourteen tons a week of foundry iron out of bog ore.

415. Clay Cold-blast Charcoal Furnace, owned and managed by Edmund Evans of Franklin and situated on Horse Creek ten miles east of Franklin Venango county Pennsylvania, was built in 1832 7½ feet across the bosh by 30 high, and made about 500 tons per annum out of lower coal measure ores until 1856, since when it has been abandoned.

416. Vanburen Cold-blast Charcoal Furnace, owned by Uhlman & Evans and situated on the river two miles southeast of Franklin Venango county Pennsylvania, was built in 1832 7 feet across the bosh by 30 high, and made in 1854 300 tons of foundry iron out of bog ore, since when it has stood abandoned, but its cinder pile will be worked over at some future time.

417. Glen Cold-blast Charcoal Furnace, built by and called commonly after Mr. Porterfield, now owned by Charles Shippen of Stapley Furnace and situated on the river twenty miles below Franklin in Venango county Pennsylvania, was abandoned in 1851 or 1852.

418. Rockland Steam Cold-blast Charcoal Furnace, owned by E. W. & H. M. Davis, Rockland P.O. Venango county Pennsylvania, managed by H. M. Davis and situated on the east bank of the Alleghany river five miles below the last and opposite the Falls, was built in 1832 8 feet across the bosh by 30 high and made in 1856 perhaps 800 tons out of limestone (buhrstone) coal measure ore.

419. Bullion Run Cold-blast Charcoal Furnace, owned

and managed by William Cross & Son, Clintonville P.O Venango county Pennsylvania, and situated on a branch of Scrubgrass creek, one mile west of the Alleghany river, and fifteen miles south of Franklin, was built in 1843 8 feet across the bosh by 30 high and made about 250 tons a year out of hard kidney ore from the coal measures around. It worked up its cinder-pile in 1857.

420. Jane Cold-blast Charcoal Furnace, owned and managed by William Cross & Son like the last, and situated on Scrubgrass creek, near Clintonville, was built in 1838 8 feet across the bosh by 30 feet in height and has made regularly each half-year blast about 500 tons.

421. Slab Cold-blast Charcoal Furnace, owned by Wattenan, Larimer & Co. and situated on East Sandy creek, three miles west of the Alleghany river and six miles southwest of Franklin, was built in 1834, 7 feet across the bosh by 30 high, and made in 1854 352 tons of metal out of flag and bog ores belonging to the coal measures. It was abandoned in 1855 but has gone into blast again.

422. Sandy Cold-blast Charcoal Furnace eight miles west-southwest of Franklin Venango county Pennsylvania, owned by C. M. Reed of Erie, stands on South Sandy creek two miles north of the Franklin-Pittsburg road and 3 miles south of the Franklin-Mercer road. It was built about 1838 8 feet wide by 33 feet high inside and made in half of 1855 400 tons of mill iron, out of coal measure fossil limestone ores within four miles to the southwest.

423. Reymilton Hot-blast Charcoal Furnace ten miles west-southwest of Franklin in Venango county Pennsylvania, owned by A. W. Raymond of Brady's Bend, and situated on Sandy creek six miles below the lake and half a mile north of the Franklin-Mercer State road, was built in 1843, 8 by 30 feet inside, and made in thirty-eight weeks of 1854 about 800 tons of iron out of coal measure ores from the south side of Sandy.

424. Orleans Hot-blast Charcoal Furnace five miles northwest of Franklin in Venango county Pennsylvania, owned by A. W. Raymond like the last, and situ-

ated on Sugar creek, two miles above French creek, was built in 1845 and experimented with until 1852 when it was abandoned. Its last size was 9 by 27½.

425. **Venango Cold-blast Charcoal Furnace,** fifteen miles northeast of Franklin in Venango County Pennsylvania, owned by John Anderson of Pittsburg and situated on Oil Creek near Dempseytown, was built in 1830, 8 by 30 feet inside, but has been abandoned many years.

426. **Valley Cold-blast Charcoal Furnace,** eight miles northwest of Franklin Venango County Pennsylvania, stands a mere ruin on French creek and in sight of the Waterford & Susquehanna as it used to be called—the Franklin and Meadville turnpike—was built and abandoned many years ago.

427. **Millcreek Cold-blast Charcoal Furnace** in Venango county, owned by Charles Shippen of Shippensville in Clarion county, was built in 1835 and abandoned.

428. **Webster Cold-blast Charcoal Furnace** in Venango county, owned by Dempsey & Wick, was built in 1839 8½ feet across the bosh by 30 high, made in 1849 500 tons and was then abandoned.

429. **Texas Cold-blast Charcoal Furnace** in Venango county, owned by Mr. Staunard, was built in 1844, 8½ feet across the bosh, and was abandoned before 1846.

430. **Union Cold-blast Charcoal Furnace,** owned by Judge McCalmont of Franklin in Venango county, was built in 1844, 8 feet bosh, made in 1849 150 tons and was then abandoned.

431. **Victoria Cold-blast Charcoal Furnace,** owned by Ritchie & Reynolds of Franklin Venango county Pennsylvania, was built in 1844, 8½ feet bosh, made in 1849 200 tons and was then abandoned.

432. **Northbend Cold-blast Charcoal Furnace,** owned by John W. Hickman of Franklin Venango county, was built in 1844, 8½ feet bosh, and abandoned before 1849.

433. **Jackson Cold-blast Charcoal Furnace,** owned by Robinson & Co. Cass P.O. Venango county Pennsylvania, was built in 1835, 8½ feet bosh, made in 1849 310 tons and was then abandoned.

434. **Liberty Cold-blast Charcoal Furnace** was built by Lowry & Co. of Meadville Sugar Creek P.O. Crawford county Pennsylvania, in 1842, 7 feet across the bosh, was abandoned in 1849 and stands in ruins on the north side of French Creek and the turnpike.

435. **Erie Cold-blast Charcoal Furnace,** owned by Charles M. Reed of Erie, Pennsylvania, was built in 1842, made in 1849 300 tons and was abandoned.

436. **Annandale Hot-blast Charcoal Furnace,** owned by Charles M. Reed of Erie, and situated on Sandy Creek above Reymilton Furnace 423, twenty miles northeast of Mercer, Mercer county Pennsylvania, was built in 1843, 7 feet across the bosh by 27 high, and abandoned before 1849.

437. Sandy Hot-blast Charcoal Furnace, No. 2, was built three years after the last, near it but of larger size, is owned by the same party and was abandoned at the same time.

438. Harry-of-the-West Steam Hot-blast Charcoal Furnace, owned by James Irwin of Bellefonte in Centre county Pennsylvania, and situated in Mercer county on the Little Chenango river, two miles west of Shakleyville, was built in 1848 9 feet across the bosh by 40 high, made in 1849 500 tons, and was abandoned and dismantled about 1852.

439. Mineral-Ridge Steam Hot-blast Charcoal Furnace (once called Eliza), owned by Ward & Co. Milestown, Mercer county Pennsylvania, on a small stream three miles from Shakelyville and a mile from Harry-of-the-West Furnace 438, fifteen miles north of Mercer, was built in 1846, and received a hot-blast in 1856; is 8½ across the bosh by 34 feet high, made about 500 or 600 tons a year, and was abandoned in the spring of 1856.

440. Mary Ann Steam Hot-blast Raw-coal Furnace, owned by Joseph Kissock of Newcastle and R. Robinson of Pittsburg, stands on the Shenango river opposite to Greenville and fifteen miles northwest of Mercer in Mercer county Pennsylvania. Built in 1846, 10 feet across the bosh by 50 high, and making 600 tons a year, out of the limestone lower coal measure ores of the neighborhood, it was abandoned January, 1855.

441. Harriet or Shenango Steam Hot-blast Raw-coal Furnace, owned by Charles M. Reed of Erie, stands a few rods distant from the last described, was built the same year, 11½ feet wide across the bosh by 45 feet high, and is said to have made in 1854 2,000 tons; but it was soon abandoned.

442. Hamburg Steam Hot-blast Raw-coal Furnace, owned by John B. Warder, stands on the Chenango river opposite to Hamburg Mercer county Pennsylvania, ten miles northwest of Mercer. Built the same year with the three last described, in 1846, 9 feet across the bosh by 40 high, it made in 1855 perhaps 1,200 tons and was dismantled and entirely abandoned the same year. Its coal was mined three miles up the canal and its (buhrstone) ore came up from Newcastle.

443. Bigbend or Shenango Steam and Water Hot-blast Charcoal Coke and Raw-coal Furnace, owned by David Hogeland, stands near the Shenango river on the Lackawannock run five miles northwest of Mercer, Mercer county Pennsylvania; was built in 1845 7½ feet across the bosh by 36 feet high, and made in 1854 1,700 tons of forge iron out of hard limestone coal measure ore mixed with some from Lake Champlain, after which it was dismantled and entirely abandoned.

444. Oregon Steam Cold-blast Charcoal Furnace, owned by W. W. Wallace of Pittsburg, stands on the Sharon-Mercer road three miles west of Mercer; was built in 1845, 8 feet across the bosh by 32 feet high and has made little or no iron since 1847. The stack was well made and the engine powerful.

445. Clay Steam Hot-blast Raw-coal Furnace, nine miles west of Mercer on Anderson's run, one mile south of the canal and three miles east of Clarksville, was built in 1845 10 feet across the bosh by 39 feet high, and made in half of 1856

902 tons of iron out of coal measure carbonate and bog ores two miles south.

446. Sharpsburg or Blanche Steam Hot-blast Raw-coal Furnace, owned by James Pierce, stands on the Shenango river in Sharpsville Mercer county Pennsylvania, thirteen miles west of Mercer. Built in 1847 11 feet across the bosh by 50 high, it made in forty weeks of 1854 perhaps 1,600 tons of iron out of hard limestone Newcastle coal measure mixed with Lake Superior ores, and was finally stopped in 1855.

447. Sharon Steam Hot-blast Raw-coal Furnace, owned by James B. Curtis, managed by J. U. Price, and situated on the Chenango river, just above the village of Sharon, fifteen miles west of Sharon, in Mercer county Pennsylvania, was built in 1846 and repaired and enlarged in 1857 to 10½ feet width across the bosh by 40 feet in height, and made in 1855 about 1,800 tons of mill iron out of hard limestone Newcastle lower coal measure ores.

448. Middlesex Steam Hot-blast Raw-coal Furnace, on Chenango river and Erie-Extension canal, five miles south of the Sharon Furnace last described, twelve miles west of Mercer, fifteen north of Newcastle and six miles east of Hubbard in Ohio, was built in 1845 10 feet wide across the bosh by 38 feet high, and in forty-two weeks of 1856 made 1,762 tons of iron out of the hematized outcrop of the blue fossiliferous limestone (buhrstone) carbonate ore of the lower coal measures from the mouth of the Conneconessing creek in Lawrence county thirty miles towards the south mixed with hard blue carbonate ores of the neighborhood.

449. Iron-city Steam Cold-blast Charcoal Furnace, owned by W. W. Wallace of Pittsburg and situated in Mercer county Pennsylvania, four miles west-southwest of Mercer, on the Mercer and West Middlesex road, was built in 1846, is 8½ feet wide across the bosh by 34 feet high, and made from 600 to 700 tons per annum until December, 1855, since when it has stood idle.

450. Mazeppa Steam Hot-blast Charcoal Furnace, owned by John J. Spearman & Co. Mazeppa P.O. Mercer county Pennsylvania, and situated two miles southeast of Mercer, and three hundred yards east of the Mercer-Butler turnpike, was built in 1846, is 9 feet across the bosh by 30 high, and made in thirty-two weeks of 1854 815 tons of iron out of buhr-

stone fossiliferous blue carbonate from the Lower coal measures mined close by.

451. Springfield Hot-blast Charcoal and Green-wood Furnace, owned by Pardon Sennett of Erie, managed by William S. Scollard, Springfield P.O. Mercer county Pennsylvania, and situated seven miles south-southeast of Mercer, on a small run half a mile from Leesbury on the Mercer-Harmony-Pittsburg road, was built in 1837, is 9 feet across the bosh by 35 feet high, and has made about 500 tons of iron per annum out of Kidney ore of the lower coal measures, the deficiency of which occasions it to be now abandoned.

452. Tremont or New Wilmington Steam Hot-blast Raw-coal Furnace, owned by Crawford & Co. of New Castle Lawrence county Pennsylvania, and situated ten miles south-southwest of Mercer, on a run half a mile south of the village and a mile above Little Neshannoc creek, was built in 1848, is 10½ feet across the bosh by 33 feet high and made in twenty-one weeks of 1856 740 tons of charcoal iron out of blue limestone carbonate of the coal measures. It is now running successfully on raw coal.

453. Willieroy Cold-blast Charcoal Furnace, owned by Stewart & Foltz Hardinsburg P.O. Lawrence county Pennsylvania and situated ten miles east of Newcastle, on Slippery rock creek at the North Western railroad location line where the Newcastle-Butler road crosses, four miles southwest of Harlandsburg, four miles north of Portersville, was built in 1854, is 10 feet across the bosh by 33 feet high, and made in twenty-two weeks of 1856 600 tons of foundry metal out of the brown hematite ore on the fossiliferous limestone of the lower coal measures mined within a mile or two all round.

454. Sophia Steam Hot-blast Coke and Raw-coal Furnace or Orizaba Iron-works, owned by Knapp, Wilkins & Co. of Pittsburg, managed by J. Crowther, Newcastle P.O. Lawrence county Pennsylvania, and situated in the town of Newcastle on the same island with the rolling mill between the canal and the Neshannoc, two miles above the junction of the two canals, was built in 1853, 13½ feet across the bosh by 45 feet high, and made in 1854 4,784 tons of forge metal out of

mixed rolling mill cinder and native coal measure carbonate ores smelted with coke and raw coal mixed.

455. **Martha Cold-blast Charcoal Furnace**, formerly owned by Power & Sons, Newcastle P.O. Lawrence county Pennsylvania and situated in the town of Newcastle, was built in 1844, 8 feet across the bosh by 36 feet high, made in 1849 200 tons and is abandoned.

456. **Wampum-run Steam Hot-blast Raw-coal Furnace**, owned by Childs, Richardson and others of Pittsburg, managed by Mr. Steward, Wampun run P.O. Lawrence county Pennsylvania, and situated seven miles below Newcastle, on the west side of the Beaver river, four miles above the mouth of the Coneconessing and 12 miles north of Brighton railroad station, was built in 1857, 14 feet across the bosh by 45 feet high, and made in sixteen weeks of 1857 about 1,200 tons of metal out of the buhrstone ore smelted with Middlesex coal.

457. **Mahoning Steam Hot-blast Raw-coal Furnace**, owned by Alexander & John M. Crawford, managed by Benjamin Crowther, Lowell P.O. Mahoning county Ohio, and situated on the south bank of the Mahoning river and canal opposite to Lowell ten miles west of Newcastle and sixty-five from Pittsburg, was built in 1845, 12 feet across the bosh by 45 feet high, and made in 46 weeks of 1857 3,311 tons of mill iron out of lower coal measure carbonate ore mixed with Lake Superior magnetic ore and rolling-mill cinder, smelted with Mount Nebo or Briar-hill coal.

458. **Poland Cold-blast Charcoal Furnace**, owned by Daniel Eaton and situated in Trumbull county Ohio six miles southeast of Youngstown, was built and twice rebuilt in 1809, 1816 and 1837, 7 feet across the bosh by about 30 high, and was abandoned after making two blasts.

459. **Falcon Steam Hot-blast Raw-coal Furnace** owned and managed by Mr. Howard, Youngstown P.O. Mahoning county Ohio and situated on the river flat, north bank, in Youngstown, between the river and canal, was built in 1856, 14 feet across the bosh by 47 high, and made in half of 1856 perhaps 1,200 tons of forge metal out of coal measure carbonate, Lake Superior magnetic ore and rolling-mill cinders mixed.

460. **Phœnix Steam Hot-blast Raw-coal Furnace** owned by Lemuel Crawford of Cleveland, managed by N. M. Jones of Youngstown Mahoning county Ohio and situated two

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hundred yards from Falcon Furnace last described and beside the canal, was built in 1854, 12 feet across the bosh by 47 high, and made in 1856 perhaps 3,000 tons of iron for the Nilestown rolling mill, out of similar mixed stock as Falcon Furnace last described.

461. Eagle or Philpot Steam Hot-blast Raw-coal Furnace, owned by Crawford & Murray, managed by T. Polluck, Youngstown P.O. Mahoning county Ohio, and situated two miles northwest of Youngstown on the south side of the railroad, and north side of the canal, was built in 1854, 12 feet across the bosh by 49 feet high, and made in 1857 about 3,284 tons of rolling-mill iron out of black band from the neighboring coal measures and Canada magnetic ores mixed, smelted with Briar-hill vein coal.

462. Briar-hill Steam Hot-blast Raw-coal Furnace, owned by David Tod, managed by W. Richards Briar-hill P.O. Mahoning county Ohio, and situated on the railroad and canal three hundred yards west of Eagle Furnace last described, was built in 1847, 14 feet wide across the bosh by 41 feet high, and made in 1857 3,161 tons of mill iron out of black band from the lower coal measures seven miles southwest, rock and kidney carbonate ores, Canada magnetic and rolling-mill cinder.

463. Meander Steam Hot-blast Raw-coal Furnace owned by Smith, Porter & Co. managed by Mr. Fuller, Orange P.O. Mahoning county Ohio, and situated nine miles southwest of Youngstown railroad station, on Meander Creek, four miles above its junction with Mahoning river, in Austin town, was built in 1857, 12 feet across the bosh by 38 feet high, and in January 1858 was making 15 to 16 tons of iron per day.

464. Mill Creek Hot-blast Raw-coal Furnace, owned last by David Grier of Pittsburg and situated in Mahoning county Ohio, three miles north of Youngstown railroad station, on Mill creek, two miles north of its junction with the Mahoning river, was built in 1835 9 feet across the bosh by about 30 high, and made perhaps 100 tons in 1855, since when it has been abandoned.

465. Musquito Creek Steam and Water Hot and Cold-blast Charcoal Furnace, owned by Warren Heaton's heirs, leased last by Robison & Battels Nilestown Trumbull county Ohio, and situated near the railroad, in Nilestown, ten miles above Youngstown on and near the mouth of Musquito creek, was built about 1812 about 9 by 32, and made in 1856 about 600 tons of iron out of bog ore and blue carbonate mixed. Once coke was tried and failed. It is abandoned.

466. Volcano Steam Hot-blast Raw-coal Furnace, owned by the Volcano Iron Company, Charles A. Crandell manager, and situated on the canal south of the village and opposite the railroad depot Massillon, Stark county Ohio, was built in 1855, 14 feet across the bosh by 45 feet high, and made in forty-eight weeks of 1856 4,755 tons of foundry iron out of clay shale kidney coal measure ores mixed with ores from Lake Superior, smelted with coal from 2 to 11 miles west.

467. Massillon Steam Hot-blast Raw-coal Furnace, owned by the Massillon Iron Company, J. E. McLain president, managed by William Polluck, Massillon, Stark county Ohio, and situated one hundred yards south of Volcano Furnace last described, was built in 1854 14 feet across the bosh by 41½ feet high, and made in twenty-six weeks of 1857 3,455 tons of iron like the furnace last described.

467.1. Coneaut Cold-blast Charcoal Furnace, Ashtabula county Ohio, was built in 1832, about 7½ feet in the bosh by 30 high, and ran several years on bog ore and was then abandoned.

467.2. Arcole Steam Hot and Cold-blast Charcoal Furnaces in Madison township Lake (late Geauga) county Ohio. The old stack was built in 1825 by Root & Wheeler, and the new one by Wilkeson & Co. in 1832. This company owned both stacks from 1830, and ran them regularly until 1851, when they were sold to the Geauga Iron Company, and have stood idle ever since. Both stacks are 9 feet in the bosh by 30 feet high, and made soft iron, thirty (30) tons a week, each, out of bog iron.

467.3. Clyde Charcoal Furnace in Madison Lake county Ohio, was built in 1832 and abandoned in 1838.

467.4. Geauga Steam and Water Hot-blast Furnace one mile north of Paineville Lake county Ohio, on Grand river, was built in 1824 (?) by an incorporated company and has been run ever since, formerly on bog ore alone, but now on bog ore mixed with Lake Superior. Production 30 to 35 tons per week.

467.5. Concord Charcoal Furnace, south of Painville in Concord, Lake county Ohio, was built in 1825 and burned down and abandoned some years since, 30 tons a week was its production.

467.6. Railroad Charcoal Furnace in Perry Geauga county Ohio, was built about 1825 by Thorndike & Drury of Boston, and has stood idle since 1838.

467.7. Middleburgh Charcoal Furnace, at Middleburgh Cuyahoga county Ohio, was built about 1836, was never very successful and is now abandoned.

467.8. Dover Charcoal Furnace, at Dover Loraine county Ohio, was built in 1834 and run on bog ore for a number of years and is now out of repair and abandoned.

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467.9. Elyria Charcoal Furnace, at Elyria Loraine county Ohio, was built in 1832 and was run with indifferent success on bog ore for a number of years and was then abandoned.

468. Vermillion Charcoal Furnace, at Florence Huron county Ohio, was built in 1834 by the Geauga Iron Company and sold in 1835 to Wilkeson & Co. who ran it with success on bog ore until within a year or two. It is now standing still.

468.1. Tilden's Charcoal Furnace in Vermillion Huron county, was built about 1854 and is now owned by Dr. Tilden of Cleveland; it uses Lake Superior ore.

468.2. Tuscarawas Steam Charcoal Furnace, in Fairfield Tuscarawas county, was built about 1830 by Christmas Hazlett & Co. and sold to the Zoar Community. It ran until 1846, and when the timber failed blew out. Coal and ore abound around it.

468.3. Zoar Charcoal Furnace, in Zoar Tuscarawas county Ohio, was built by the Zoar Community and ran many years until charcoal failed. Ore and bituminous coal are abundant near it.

468.4. Middlebury Charcoal Furnace, in Middlebury Summit county Ohio, and

468.5. Tallmadge Charcoal Furnace in Tallmadge Summit county Ohio, were old works in 1830, smelting the coal measure carbonate ores with charcoal, and both went out of blast about 1835.

468.6. An old Furnace still stands in Hartford, Mahoning county Ohio.

469. Akron Hot-blast Charcoal Furnace, owned by Tod, Rhodes and others and situated on the Tuscarawas, twenty miles above Massillon opposite Rawson's Mill in Summit county Ohio, was built before 1840 10 feet across the bosh by 36 high, and was dismantled in 1850 having made the year before perhaps 1,000 tons.

470. Dover Steam Hot-blast Raw-coal Furnace, twenty miles south of Massillon, at Dover in Tuscarawas county Ohio, owned formerly by the Tuscarawas Iron Company and managed by Mr. J. E. Hicks, is 12 feet across the bosh by 45 feet high, and made in 1856 perhaps 900 tons of iron out of the same ores as those used at Massillon (466 and 467). It is probably abandoned.

471. Dresden Cold-blast Charcoal Furnace, sixteen miles north of Zanesville in Muskingum county Ohio, owned by Spaulding & Co. and situated near Hopewell Falls of Licking river, was built about 1847 10 feet across the bosh by 45 feet high and made a good deal of iron, but was abandoned in 1850.

472. Dillon's Cold-blast Charcoal Furnace, four miles northwest of Zanesville in Muskingum county Ohio, owned by Mr. Buckingham of Zanesville, and situated with a forge on the Columbus railroad at the Falls of Licking, was built thirty or forty years ago, 6 by 30 feet inside, and afterwards enlarged to about the same size as Dresden last described. It made perhaps 1,000 tons of forge iron per annum and was not abandoned until 1850 or later.

473. Mary Ann Steam Hot-blast Charcoal Furnace, ten miles northeast of Newark in Licking county Ohio, owned by Dille B. Moore, and situated on Rock Fork of Licking, was built in 1816 and remodelled to a steam furnace about 1847. She made perhaps 1,000 tons per annum out of pot and rock ores from the outcrop

of the lower coal measures, but no limestone ore. It is said to have become lately a stone coal furnace.

474. **Logan Steam Hot-blast Charcoal Furnace,** owned by the Logan Furnace Company, Roberts & Co. managed by F. Case, Logan P.O. Hocking county Ohio, and situated on the bank of the Hocking canal just outside the village of Logan to the northwest and in Falls township, was built in 1855 9 feet across the bosh by 32 feet high, and made in thirty weeks of 1856 about 1,600 tons of machine iron from horizontal coal-measure carbonate ores half a mile and more around the furnace.

475. **Hocking Steam Hot-blast Charcoal Furnace,** owned by the Hocking Iron Company, Peter Haydn of Columbus president, W. M. Moore secretary, managed by W. H. Haydn, Hocking county Ohio, and situated on the canal, seven miles southeast of the Logan railroad station, in Green township, was built in 1852 9 feet across the bosh by 32 feet high, and made in twenty-one weeks of 1857 about 1,000 tons of iron from horizontal coal-measure block and limestone carbonate orebeds round the neighborhood. Will probably use coke and raw-coal hereafter.

476. **Fivemile Steam Hot-blast Charcoal Furnace,** owned by the Fivemile Furnace Company, R. Adcock president, Webster & Co. lessees, Wm. M. Bowen manager, Hocking county Ohio, and situated on Fivemile Creek and on the Scioto and Hocking Valley railroad five miles south of Logan station and three miles from Hocking Furnace last described, was built in 1855 10 feet across the bosh by 33 feet high, and made in twenty-one weeks of 1856 1,035 tons of foundry iron for Zanesville, Columbus and Cleveland, out of horizontal coal-measure carbonate ores, five beds, around.

477. **Bigsand Steam Hot and Cold-blast Charcoal Furnace,** owned by the Bigsand Iron Company, Bartlett, Dannar & Co. managed by S. J. Summinger, Athens P.O. Vinton county Ohio, and situated on a branch of Big Raccoon creek, one and a quarter miles north of the Cincinnati and Marietta railroad, in township No. 11, R. 16, eleven miles east of McArthur station and fourteen west of Athens, was built in 1854 10½ feet across the bosh by 36 feet high, and made in thirty weeks

of 1856 about 1,800 tons of soft grey iron out of horizontal coal measure limestone ore mined all round.

478. Zaleski Steam Hot-blast Raw-coal Furnace, owned by the Zaleski Iron Company, H. B. Robson financial agent, managed by Mr. Walters, Zaleski P.O. Vinton county Ohio, and situated half way between Vinton and Bigsand Furnaces, a mile from Zaleski station, where the machine shops, foundries, rolling mill, etc. are being built, was built in 1858, 13 feet across the bosh by 46 feet high, the first of three stacks, to run on raw-coal and limestone, clay and silicious ball ores of the horizontal coal measures in the hills close by.

479. Vinton Steam Hot and Cold-blast Charcoal Furnace, owned by Means, Clark & Co. managed by Cyrus Newkirk, McArthur P.O. Vinton county Ohio, and situated two miles south of the railroad station, seven miles northeast of Hambden station, was built in 1854 11 feet across the bosh by 32½ feet high and made in forty-seven weeks of 1857 about 3,100 tons of foundry iron out of coal-measure limestone ore exclusively, abundant in the neighborhood.

480. Hambden Steam Hot and Cold-blast Charcoal Furnace, owned by Damarin, Tarr & Co. managed by McKean, Reed's Mills P.O. Vinton county Ohio, and situated more than a mile southeast of Hambden village railroad station, was built in 1854, 11 feet across the bosh by 33 feet high, and made in 1857 2,157 tons of hot and cold-blast iron out of coal measure limestone and block ores mixed.

481. Eagle Steam Cold-blast Charcoal Furnace, owned by Bentley, Benner, Bundy and others, managed by William B. Dennis, Reed's Mills P.O. Vinton county Ohio, and situated on the Hambden-Pomeroy main road, between the waters of Big and Little Raccoon creeks, six miles southeast from Hambden railroad station, was built in 1854 11 feet bosh, and made in twenty-eight weeks of 1856 1,725 tons of iron out of coal measure limestone ores all round the furnace.

482. Cincinnati Steam Hot-blast Charcoal Furnace, owned by the Cincinnati Furnace Company, Westfall, Dungan and Stewart, managed by J. B. Royer, Jackson P.O. Jackson county Ohio, and situated on Pigeon creek and Cincinnati and

Marietta railroad six miles west of Hambden station and twenty-five miles east of Chilicothe, was built in 1854 13 feet in the bosh by 40 high, and made in thirty-two weeks of 1856 2,560 tons of iron out of coal-measure block and limestone ores mixed, from the hills around and lately from the mines at Vinton Furnace.

483. Iron Valley Steam Cold and Hot-blast Charcoal Furnace, owned by the Iron Valley Furnace Company, Thompson, Lasley & Co. managed by S. Churchill, Berlin P.O. Jackson county Ohio, and situated on Mulligy creek six miles southeast of Hambden village railroad station and seven east of Berlin station, was built in 1853 11 feet in the bosh by 38 feet high and made in 1856 about 2,000 tons of iron out of limestone ore mixed with a little block ore, from the surrounding coal measures.

484. Latrobe Steam Cold-blast Charcoal Furnace, owned by Bundy, Austin & Co. managed by Drew Ricker, Berlin P.O. Jackson county Ohio, and situated two miles southeast of Berlin station on the Hocking Valley railroad, was built about 1854 10 feet in the bosh by 35 feet high and made in forty-four weeks of 1857 2,025 tons of iron out of coal measure limestone ore mixed with a little blue ore, from diggings around.

485. Buckeye Steam Hot and Cold-blast Charcoal Furnace, owned by Newkirk, Daniels & Co. Buckeye Furnace Company, managed by Warren Murfin, Berlin P.O. Jackson county Ohio, and situated five miles south of Iron Valley Furnace 483, on Little Raccoon creek, six miles east of Berlin railway station, was built in 1853, is 11 feet in the bosh by 34 feet high, and made in forty-two weeks of 1855 1,840 tons of iron out of horizontal limestone ore of the surrounding coal measures.

486. Keystone Steam Hot and Cold-blast Charcoal Furnace, owned by E. B. Greene & Co. of Portsmouth, managed by M. Churchill, Jackson county Ohio, and situated on Little Raccoon creek eleven miles east of Jackson railway station, was built in 1848 10 feet across the bosh by 35 feet high, and made in 1856 2,407 tons of hot and cold-blast iron out of limestone ore from the horizontal coal measures within four miles west.

487. Young America Steam Hot-blast Raw-coal Furnace, owned by Powel, Oakes & Co. managed by Peter Powel, Jackson C.H. Jackson county Ohio, and situated on the Hocking Valley railroad three miles east of Jackson Court-House, was built in 1857 13 feet across the bosh by 48 feet high, and made 14 tons of iron a day out of block ore from the lower coal measures in the hill alongside.

488. Diamond, formerly Saltlick, Steam Hot-blast Raw-coal and Charcoal Furnace, owned by Grattan, Hoffman & Co. managed by Peter Cowell, Jackson P.O. Jackson county Ohio, and situated on Saltlick waters and on the Parkersburg, Hillsborough and Cincinnati railroad location line, one mile west of Jackson railway station, was built in 1856 12 feet in the bosh by 41½ feet high, and made in perhaps half of 1856 perhaps 1,000 tons of iron out of coal measure ore mostly brought by railroad from six to ten miles' distance.

489. Madison Steam Hot and Cold-blast Charcoal Furnace, owned by Peters, Terry & Co. Mr. Terry agent at Portsmouth, managed by Jacob Ricker, Jackson county Ohio, and situated two and a half miles east of Crossroads Hocking valley railway station, was built in 1854 11 feet across the bosh by 35 feet high and made in twenty-six weeks of 1857 about 2,500 tons of iron out of surrounding coal measure ores.

490. Limestone Steam Hot and Cold-blast Charcoal Furnace, owned by the Limestone Furnace Company, Newson, Evans & Co. managed by William J. Evans, Oakhill P.O. Jackson county Ohio, and situated two and a half miles east of Oakhill Hocking Valley railroad station, on Grassy fork of Symme's creek, was built in 1854, 11½ feet across the bosh by 39 feet high and made in about half of 1856 perhaps 1,800 tons of iron out of surrounding horizontal lower coal measure ore.

491. Jefferson Steam Cold-blast Charcoal Furnace, owned by the Jefferson Furnace Company, managed by George W. Baker Oakhill P.O. Jackson county Ohio, and situated one and a half miles west of Portland Hocking Valley railroad station on the black fork of Symme's Creek, was built in 1854 11 feet across the bosh by 37 feet high, and made in about half of 1856 1,565 tons of soft grey iron out of coal measure limestone ores within two miles around.

492. Jackson Steam Hot-blast Charcoal Furnace, owned by the Jackson Furnace Company, Davis & Tracy, Jackson P.O. Jackson county Ohio, and situated about seven miles northwest of Monroe Furnace next to be described, was built in 1837 9½ feet across the bosh by 33 feet high and made in 1857 about 2,700 tons of iron out of lower coal measure ores.

493. Monroe Steam Hot-blast Charcoal Furnace, owned by McConnell, Bolles & Co. managed by Mr. Gilbert Jackson P.O. Jackson county Ohio, and situated quarter of a mile north of its Hocking Valley railroad station, was built in 1855 12 feet across the bosh by 40 high and made in forty-three weeks of 1857 3,700 tons of iron out of limestone ore of the surrounding coal measures.

494. Cambria Steam Cold-blast Charcoal Furnace, owned by David Lewis & Co. managed by D. T. Lewis, Oak-hill P.O. Jackson county Ohio, and situated one and a half miles southeast of its Hocking Valley railroad station, twenty-five miles from Portsmouth, was built in 1854 10½ feet across the bosh by 30½ feet high and made in 1857 perhaps 1,950 tons of iron out of limestone ore and some blue ore of the surrounding coal measures.

495. Gallia Steam Warm-blast Charcoal Furnace, owned by Bentley, Campbell & Co. managed by Mr. Bentley, Gallia P.O. Gallia county Ohio, and situated five miles south of its Hocking Valley railroad station, the same as Cambria, was built about 1847 10 feet across the bosh by 30 high and made in 1857 2,300 tons of iron out of limestone ore and blue ore of the lower coal measures, mixed.

496. Washington Steam Cold-blast Charcoal Furnace, owned by J. Peters & Co. S. McConnell, financial agent, managed by William Colvin, Ironton P.O. Lawrence county Ohio, and situated two miles south of the same station as the last, and three miles south of Monroe Furnace 493, was built in 1852 11 feet bosh by 34 feet high and made in thirty-seven weeks of 1857 1,967 tons of iron out of limestone coal measure ores.

497. Pioneer Steam Hot-blast Raw-coal Furnace, owned by Ormsby, Colvin & Reed, managed by William Colvin Ironton P.O. Lawrence county, Ohio. and situated in Washing-

ton Township, three miles southeast of its Hocking Valley railroad station, was built in 1856 about 14 feet in the bosh by perhaps 45 feet high and made in 1857 a little iron out of coal measure ores.

498. Olive Steam Cold-blast Charcoal Furnace, owned by Campbell, Peters, Bimpson & McGugin, managed by William N. McGugin, Ironton P.O. Lawrence county Ohio, and situated in the southeast corner of Sec. No. 34, town 4, R. 18, Chilicothe land district and on the railroad nineteen miles north of Ironton, was built in 1847 9 feet across the bosh by 36 feet high and made in thirty three weeks of 1854 1,932 tons of grey iron out of hematite ore from the outcrop of some of the beds of the lower coal measures.

499. Buckhorn Steam Hot-blast Charcoal Furnace, owned by Seeley, Willard & Co. managed by Boudinot Seeley, Ironton P.O. Lawrence county Ohio, and situated one mile west of the Ironton railroad fourteen miles north of Ironton, on a branch of Pine creek, two miles southwest of Olive Furnace last described, was built about in 1836 10 feet in bosh by 36 feet high and made in half of 1856 1,450 tons of iron out of blue carbonate ore of the lower coal measures.

500. Mountvernon Steam Hot-blast Charcoal Furnace, owned by Campbell, Ellison & Co. managed by Robert Scott, Ironton P.O. Lawrence county Ohio, and situated two miles southeast of Buckhorn Furnace last described, on the railroad thirteen miles from Ironton, was built in 1835 10½ feet bosh by perhaps 36 feet high and made in half of 1855 2,144 tons of foundry iron out of limestone coal measure ores mined close by.

501. Oakridge Steam Hot and Cold-blast Charcoal Furnace. owned by Stetson, Bishop, Mitchell and Mather, managed by O. M. Mitchell, Ironton P.O. Lawrence county Ohio, and situated on Elkin's creek one mile above its junction with Symme's creek, six miles east of the Ironton railroad, twelve miles northeast of Ironton, was built in 1856 11 feet bosh by 44 feet high and made in 1857 450 tons of iron out of various ores from the middle coal measures.

502. Centre Steam Hot-blast Charcoal Furnace, owned by Robert B. Hamilton, managed by S. McGugin, Ironton P.O.

Lawrence county Ohio, and situated two miles west of the railroad, ten miles north of Ironton, was built in 1838, is 9½ feet bosh by 35 feet high and made in 1855 about 2,400 tons of iron from lower coal measure ores around.

503. **Lawrence Steam Hot-blast Charcoal Furnace**, owned by Culbertson, Means & Co. managed by J. Culbertson, J. E. Clark agent, Ironton P.O. Lawrence county Ohio, and situated one mile east of the railroad eight miles north of Ironton, was built in 1834 10 feet across the bosh by 35 feet high and made in 1856 2,434 tons of iron from lower coal measure ores around.

504. **Etna Steam Cold-blast Charcoal Furnace**, owned by J. Ellison, S. W. Dempsey and James Rogers, managed by J. Ellison, Ironton P.O. Lawrence county Ohio, and situated two miles east of the railroad, seven miles north of Ironton, on the east fork of Pine creek, was built about in 1832 is 10½ feet wide across the bosh and made in forty weeks of 1856 2,240 tons of iron out of brown hematite outcrop ore of the lower coal measures.

505. **Vesuvius Steam Hot-blast Charcoal Furnace**, owned by Dempsey & Co. and managed by Washington Boyd, Ironton P.O. Lawrence county Ohio, and situated two miles east of the railroad six miles north of Ironton on Storm's creek crossing of the Marion-Portsmouth road, was built about 1834 10½ feet bosh by 31 feet high and made in thirty-seven weeks of 1854 2,091 tons of mill iron out of brown hematite lower coal measure outcrop ore within two miles.

506. **Pine-Grove Steam Hot-blast Charcoal Furnace**, owned by Hamilton, Peebles & Coles, managed by John F. Peebles, Hanging Rock P.O. Lawrence county Ohio, and situated two miles west of the railroad six miles north of Ironton, on Sperry's Fork of Pine creek, five miles from the Ohio river, was built in 1828, rebuilt in 1834, again in 1840, 10½ feet bosh by 34 feet high, and made in thirty-eight weeks of 1854 2,688 tons of iron out of lower coal measure limestone and block ores.

507. **Union Steam Hot-blast Charcoal Furnace**, owned by Sinton & Means, managed by J. W. Means Hanging Rock P.O. Lawrence county Ohio, and situated three miles west of Pine Grove Furnace last described, was built in 1826 10 feet in

the bosh by 35 in height and made in 1854 perhaps 2,000 tons of iron out of lower coal measure ores but the furnace must wait for a second growth of timber or blow in on coke or coal.

508. Lagrange Steam Cold-blast Charcoal Furnace, owned by the Ohio Iron and Coal Company, John Campbell president, Ironton P.O. Lawrence county Ohio, and situated on the railroad one mile north of Ironton, was built in 1836 10 feet bosh by 32 feet high and made in 1854 about 1,000 tons of iron out of lower coal measure limestone ore mixed with some block. The furnace was abandoned in 1856 for want of timber and must be rebuilt to run on raw coal.

509. Hecla Steam Hot and Cold-blast Charcoal Furnace, owned by Campbell, McCullough & Co. managed by John Wilson, Ironton P.O. Lawrence county Ohio, and situated three miles northeast of Ironton, was built in 1835 10 feet across the bosh by 35 feet high and made in about thirty weeks of 1857 1,760 tons of iron out of lower coal measure ores.

510. Ohio Steam Hot-blast Charcoal Furnace, owned by Sinton and Means, managed by George B. Sparks, Haverhill P.O. Scioto county Ohio, and situated five miles northwest of Hanging Rock, on Gennatt's creek, three miles from the Ohio river was built about 1850 with a 10½ feet bosh and made in thirty-four weeks of 1856 2,168 tons of iron out of lower coal measure outcrop hematite ores from the east.

511. Howard Steam Hot-blast Charcoal Furnace, owned by Campbell, Woodrow & Co., managed by H. A. Webb, Wheelersburg P.O. Scioto county Ohio, and situated four miles west of Mount Vernon Furnace 500, on Pine creek, five miles from the Hocking Valley railroad, twenty east of Portsmouth, was built about in 1853 11 feet bosh by 38 feet high and made in thirty-seven weeks of 1856 about 2,200 tons of iron out of lower coal measure outcrop hematite and limestone fossil ores, mixed with some silicious block.

512. Clinton Steam Hot-blast Charcoal Furnace, owned by Gliddon, Crawford & Co. managed by S. S. Gliddon, Ironton P.O. Lawrence county Ohio, and situated in Scioto county, one mile south of Howard Furnace 511, on Pine or Hale's creek, nine miles south of east from Wheelersburg on the Ohio, was built about in 1832, is 10 feet across the bosh by 32 feet high and made in forty-two weeks of 1854 2,920 tons of iron out of limestone and brown hematite crop ores from the surrounding coal measures.

513. Bloom Steam Hot-blast Charcoal Furnace, owned by G. S. Williams & Co. Portsmouth P.O. Scioto county Ohio, and situated two miles south of its Hocking Valley railroad station twenty miles east of Portsmouth, was built about 1832 9¼ feet across the bosh by 35(?) feet high and made in 1856 about 1,800 tons of iron out of lower coal measure block and limestone ores.

514. Scioto Steam Hot-blast Charcoal Furnace, owned by J. V. Robinson & Sons and others, managed by Charles Gliddon Portsmouth P.O. Scioto county Ohio, and situated on the Scioto and Hocking Valley railroad fifteen miles from Portsmouth, was built about 1830 10 feet across the bosh by 35 feet high and made in forty-eight weeks of 1854 3,041 tons of iron out of lower coal measure outcrop hematite and limestone ores around.

515. Harrison Steam Hot-blast Charcoal Furnace, owned by H. Spellman, S. R. Ross and others, managed by H. Spellman, Sciotoville P.O. Scioto county Ohio, and situated five miles north of the Sciotoville Hocking Valley railroad station twelve miles east of Portsmouth, was built about 1853 10¼ feet bosh by 38 feet high and made in about thirty weeks of 1855 about 2,300 tons of iron out of surrounding coal measure block and limestone ores.

516. Franklin Steam Hot-blast Charcoal Furnace, owned by John F. and Oran B. Gould, managed by the latter, Franklin P.O. Scioto county Ohio, and situated on the road from Ironton to Portsmouth, sixteen miles from the latter place and half a mile from its river landing, was built in 1826 9½ feet in the bosh by 28 feet high and made in half of 1856 2,277 tons of iron out of lower coal measure outcrop brown hematite and limestone ores.

517. Junior Steam Hot-blast Charcoal Furnace, owned by Gliddon, Murfin & Co. managed by James Murfin, Junior P.O. Scioto county Ohio, and situated two miles east of Franklin Furnace last described, on Genatt's creek, was built in 1828 9½ feet across the bosh by 33 feet high, and made in forty weeks of 1854 3,016½ tons of iron out of lower coal measure block limestone and crop hematite ores.

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518. Empire Steam Hot-blast Charcoal Furnace, owned by Gliddon, Murfin & Co. managed by O. H. Gliddon, Junior P.O. Scioto county Ohio, and situated on Poplar Fork of Pine creek, 7 miles northeast of the Ohio river, fourteen southwest of Ironton, was built in 1847 10 feet across the bosh by 31 feet high, and made in thirty-one weeks of 1856 2,078 tons of iron out of lowest coal measure block and crop hematite ores.

519. Brushcreek Cold-blast Furnace, in Adams county Ohio, on Brush Creek twelve miles from the Ohio river, was built in 1812 and run in 1813 by Mr. James Rogers, now living at Hanging Rock. It and the two following furnaces were deserted soon after the Ironton and Hanging Rock ores were discovered and worked, that is about the year 1826, when the Messrs. Hamilton, Andrew Ellison, Archibald Paull, and Mr. Rogers, who had gone from Pennsylvania to Adams county, began to operate in Lawrence county. Andrew Dempsey came about the same time direct from Pennsylvania. Thos. Means' father, Governor McArthur, and Thos. James, of Chilicothe, dec., were all three owners in Adams Co.

520. Old Steam Cold-blast Charcoal Furnace, in Adams county Ohio, was built in 1816 and abandoned about 1826.

221. Marble Cold-blast Charcoal Furnace, on Brush Creek in Adams county Ohio, ten miles above Brushcreek Furnace 519, was also built in 1816 and abandoned about 1826.

521.1. Globe Furnace, six miles northwest of Greenupsburg, on Tygart's Creek in Greenup county Kentucky. Abandoned.

522. New Hampshire Steam Hot-blast Charcoal Furnace, owned by Seaton, White, Davison & Culbertson, managed by T. Davison, Quincy P.O. Greenup county Kentucky, and situated on a branch of Tygart's creek, twelve miles west of Greenupsburg and ten miles south of east from Quincy on the river, was built in 1846 (?) 10 feet across the bosh by 32 feet high and made in twenty-two weeks of 1854 970 tons of iron out of lower coal measure carbonate and fossil ores in the hills around.

523. Kenton Steam Cold-blast Charcoal Furnace, owned by John Waring & Sons, managed by John Waring Quincy P.O. Lewis county Ohio, and situated in Greenup county Kentucky, on Big White-oak creek and State road fifteen miles west of Greenupsburg six miles from the Ohio, was built in 1854 11 feet across the bosh by 36 feet high and made in twenty-seven weeks of 1856 1,500 tons of iron out of lower coal measure carbonate, fossil and crop hematite ores from the hills around.

524. Raccoon Steam Hot-blast Charcoal Furnace, owned by Barr, McGrew & Co. managed by William H. McGrew, Greenupsburg, Greenup county Kentucky, and situated on Raccoon Creek, eight miles southwest of Greenupsburg, was built in 1831 (?) 10½ feet across the bosh by 34 feet high, and made in about thirty-five weeks of 1854 about 2,000 tons of iron out of lower coal measure block, kidney and crop hematite ores from the hills around.

525. Buffalo Steam Warm-blast Charcoal Furnace, owned by P. C. Vandyke & Co. managed by P. C. Vandyke, Greenupsburg, Greenup county Kentucky, and situated nine miles south of Greenupsburg, was built in 1852 10 feet across the bosh by 35 feet high and made in 1854 2,197 tons of iron out of the surrounding lower coal measure ores.

526. Argolite Steam and Water Cold-blast Charcoal Furnace, owned by Mr. Trimble last, and situated in Greenup county Kentucky, was situated ten miles south of Greenupsburg, but nothing but an old mill marks the place. Excavated from the rock, 6 by 25, (?) in 1818 by Richard Dearing, it was abandoned in 1837.

526.5. Pactolus Furnace and Forge on the Sandy above Argolite Furnace last described and built just after it by Ward & McMurtrie was abandoned twenty years ago.

527. Caroline Steam Cold-blast Charcoal Furnace, owned by W. Wurtz & Co. managed by M. R. King, Greenupsburg, Greenup county Kentucky, and situated three miles above Greenupsburg, one and a half mile back from the Ohio River, was built in 1833 10 feet across the bosh by 35 feet high, and made in 1857 perhaps 1,200 tons of cold short iron out of lower coal measure limestone ore within three miles east and south.

528. Steam Steam Hot-blast Charcoal Furnace, owned by Wurtz, Spaulding & Co. managed by J. S. Jones, Greenupsburg Greenup county Kentucky, and situated four miles above Greenupsburg, two and a half miles back from the Ohio River, was built in 1817, rebuilt in 1854 10 feet across the bosh by 35 feet high and made in 1854 perhaps 1,200 tons of iron out of surrounding lower coal measure ores. Furnace runs on a second growth of timber.

529. Amanda Steam Cold-blast Charcoal Furnace, owned by Childs, Rogers, Walker & Co. managed by G. Walker,

Amanda P.O. Greenup county Kentucky, the only furnace situated on the Ohio River shore, nine miles above Greenupsburg and opposite to Ironton, was built in 1831 10 feet across the bosh by 35 feet high, and made in 1854 about 200 tons of iron and nothing since. Its ores are carbonate, limestone and crop hematites from the horizontal lower coal measures in the river cliffs.

530. Bellefonte Steam Hot-blast Charcoal Furnace, owned by Means, Russell & Means, managed by John Russell, Ashland P.O. Greenup county Kentucky, and situated on Hood's Creek, twelve miles above Greenupsburg two and a half miles back from the Ohio River, at Ashland, was built in 1828 10 feet across the bosh, and made in thirty-two weeks of 1857 1,721 tons of iron out of lower coal measure limestone and crop hematite ores in the surrounding hills.

531. Clinton Steam Cold-blast Charcoal Furnace, owned by J. Burwell & Co. managed by J. Burwell, Ashland P.O. Greenup county Kentucky, and situated four miles south from Bellefonte Furnace last described, was built in 1833 10 feet across the bosh and made in 1857 about 1,500 tons of iron out of lower coal measure limestone ore hauled from the nearly horizontal outcrops west of the furnace which stands like Oakridge 501, in the middle coal measures.

532. Pennsylvania Steam Hot-blast Charcoal Furnace, owned by Ross, Lampton & Co. managed by William H. Lampton, Greenupsburg P.O. Greenup county Kentucky, and situated two miles north of Steam Furnace 528, on William's Creek, six miles west of its railway station five miles south of Ashland, was built in 1844 11 feet across the bosh by 35 feet high, and made in thirty-one weeks of 1855 1,386 tons of iron out of lower coal measure limestone, block and crop hematite ores within four miles around.

533. Buena Vista Steam Hot-blast Charcoal Furnace, owned by H. Means & Co. managed by John Rhoads, Catletsburg P.O. Greenup county Kentucky, and situated on a branch of Little Sandy river four miles south of Pennsylvania Furnace last described, five miles west of its railway station ten miles southwest of Ashland, was built in 1848 10 feet across the bosh by 35 feet high, and made in thirty-two weeks of 1854 1,649

tons of iron out of brown hematite crop ore from the horizontal lower coal measures around.

534. Greenup Steam Hot-blast Charcoal Furnace, owned by Wilson, Baird & Co. managed by A. J. Bell, Greenupsburg P.O. Greenup county Kentucky, and situated on the Little Fork of Sandy river three miles west of Pennsylvania Furnace 532, was built in 1845 '46 11 feet across the bosh by 37 feet high and made in about thirty-four weeks of 1856 about 2,600 tons of iron out of lower coal measure limestone and some block ores from the hills around.

535. Laurel Steam Hot-blast Charcoal Furnace, owned by Wurtz & Brothers, managed last by J. S. Jones, Greenupsburg Greenup county Kentucky, and situated twelve miles southwest of Greenupsburg, was built in 1849 10 feet across the bosh by 40 high and made in thirty-one weeks of 1855 2,150 tons of iron from lower coal measure block and kidney carbonate ores from the hills around.

536. Boone Steam Hot-blast Charcoal Furnace, owned by Eifurt, Watkins & Co. Boone P.O. Greenup county Kentucky, and situated on Grassy creek fourteen miles southwest of Greenupsburg, about forty paces from the Carter county line, was built in 1857 11 feet across the bosh by 40 high and made in 1857 perhaps 500 tons of iron out of lower coal measure ores.

537. Star Steam Hot and Cold-blast Charcoal Furnace, owned by Lampton, Nichols & Co. managed by R. W. Lampton Cattelsburg P.O. Carter county Kentucky, and situated four miles southwest of Buena Vista Furnace 533, on Williams Creek and railroad located line fourteen miles from Ashland, was built in 1848 11½ feet across the bosh by 36 feet high and made in 1857 about 2,050 tons of iron out of lower coal measure ores.

537.5. Campbranch or Farewell Furnace near the Carter county line fourteen miles from Greenupsburg on Little Sandy river was built by David and John Trimble and abandoned thirty or forty years ago.

538. Mount Savage Steam Hot-blast Charcoal Furnace, owned by R. M. Biggs, managed by Andrew Biggs, Ashland P.O. Greenup county Kentucky, and situated in Carter county on Straight creek, three miles south of its rail-

road station, six miles east of Grayson and eight miles south of Star Furnace last described, was built in 1847, rebuilt in 1853 10 feet across the bosh by 31 feet high and made in thirty-six weeks of 1856 2,031½ tons of iron out of lower coal measure red and blue limestone ore and sandy and argillaceous block carbonate ores from the hills around.

539. Sandy Steam Hot-blast Charcoal Furnace, owned by William Wutz of Cincinnati, managed by J. S. Jones, Bottsfork P.O. Lawrence county Kentucky, and situated on Bolt's creek five miles west of Big Sandy ten miles east of Star Furnace 537, was built in 1849 10½ feet across the bosh by 32 feet high and made in 1854 about 1,000 tons and nothing since out of lower coal measure refractory ores.

540. Carter's Caney Charcoal Furnace, owned by R. and A. S. Carter, Bath county Kentucky, and situated fourteen miles east of Owingsville on Caney Fork of Licking river five miles east of Olympian Springs and near the White Sulphur Springs 53 miles east of Lexington, made a blast in 1857 '8, on limestone hematite ore from the lower coal measures.

540.5. Clearcreek Charcoal Furnace on Licking river is owned by Hurte and Berry, Hugh Barr agent, Cincinnati, Ohio.

541. Old Slate Charcoal Furnace, in Bath county Kentucky, and situated on the State branch of Licking river five (?) miles northeast of Owingsville, is said to be the oldest iron works in Kentucky, built by the government troops in 1791, and ran until 1838 upon Magnesian limestone ore in the Upper Silurian or Clinton Group Formation No. V.

542. Millercreek Old Charcoal Furnace in Estill county Kentucky, eight miles northeast of Irvine, stands at the head of Miller's creek a small branch of the Kentucky river, about fifty miles due south of Maysville on the Ohio river, and used to run on subcarboniferous grey carbonate ore of Formation XI.

543. Cottage Steam Hot-blast Charcoal Furnace, owned by J. C. Mason and Levi Wheeler, Irvine P.O. Estill county Kentucky, was built in 1856 to run upon the same subcarboniferous or subconglomerate grey carbonate ore of Formation XI. and made in eighteen weeks of 1857 725 tons of iron.

544. Estill Steam or Red River Steam Cold-blast Charcoal Furnace, owned by Josiah A. Jackson and J. W. Jones, managed by the latter, Redriver P.O. Estill county Kentucky, and situated on Miller's and Hardwick creek 10m. S.S.E. of the Red River Iron Works, and twelve miles northeast from Irvine, was built in 1830, rebuilt in 1849 10½ feet across the bosh by 33 feet high and made in eighteen weeks of 1857 693 tons of carwheel iron out of ore mined from the surface of limestone.

545. **An Old Furnace** in Russell county Kentucky, five miles south of Jamestown, was in operation twenty-five years ago, running on the ore found on the table land near the Creelsborough-Jamestown road, in red clay.

546. **Belmont Steam Hot-blast Charcoal Furnace,** owned by J. B. Alexander & Co. of Louisville and managed by W. Patterson of Belmont Furnace P.O. Bullitt county Kentucky, stands twenty-six miles south of Louisville, was built in 1844, rebuilt in 1853, and bought with the two furnaces next to be described by its present owners in March 1858, is 10 feet wide across the top of the bosh by 33 feet high inside, and made in six months of 1857 1,140 tons of machinery and mill iron out of carbonate ores, abundant in the grey or ash colored shales [of Formation VIII.] overlying the black Devonian slate [Formation VIII.] in the southeast part of the range of the knobs of Bullitt, extending along the waters of Cane river southeastwardly into Nelson county, and therefore identical with the peculiar ores of Huntingdon county Pennsylvania above No. VII. or the Oriskany Sandstone.

547. **Salt River Steam Cold-blast Charcoal Furnace,** owned by the same as and situated three miles to the northwest of Belmont Furnace last described, and one mile from the Louisville and Nashville railroad, was built earlier (in 1832), is of the same size and used the same ore until it stopped finally in 1853. It made a tough forge iron.

548. **Nelson Steam Hot-blast Charcoal Furnace,** owned also by the same, but managed by J. B. Patterson of New Haven P.O. Nelson county Kentucky, is forty miles south of Louisville, on the Lebanon branch railroad; it was built in 1834 and rebuilt in 1853, the size of the other two 10 by 33, and made in twenty-seven weeks of 1857 1,256 tons forge iron out of similar Devonian carbonate ore from Salt Spring Hollow where it is a solid plate from twelve to sixteen inches thick, and from banks a few hundred yards from the furnace.

549. **Alexander's Steam Hot-blast Stone Coal Furnace,** owned by R. S. C. A. Alexander, and managed by Wm. Torrance of Greeneville Muhlenburg county Kentucky, was built in 1857 on the south bank of Green river at a point formerly called Paradise, now Airdrie, 35 miles above Lock 2 (Ramsay), 10 miles below the mouth of Mud river (Lock 3), 4 miles above the crossing of the Lexington and Nashville railroad line, 10 miles by river above Lewisport, and 10 miles east-northeast of Green-

ville. It was built 15½ feet across the bosh by 48 feet high, for bituminous coal from the Airdrie bed and black band iron ore, both mined close by the furnace. An old furnace out of blast for fifteen years was bought by Mr. Alexander and its machinery removed.

550. **Old Bucknor Cold-blast Charcoal Furnace,** seven miles south-southeast of Greenville Muhlenburg county Kentucky, on Battish creek, had plenty of slaty black band ore and also fossil ore within two miles.

551. **Hurricane Steam Cold-blast Charcoal Furnace,** on Hurricane creek 2½ miles from its mouth and the Ohio river, commonly known as the "Jackson Furnace," the original structure having been built by Andrew Jackson, Jun. in 1853, is now owned by John W. Walker of Nashville and J. R. Hassell of Marion P.O. Crittenden county Kentucky. Rebuilt in 1856 10 feet wide across the top of the bosh by 34 feet high inside, it made in six months of 1857 about 1,200 tons of soft metal used by the rolling mills for mixing, out of brown hematite ore from the Jackson bank one and a half miles distant.

552. **Crittenden Steam Cold-blast Charcoal Furnace** is the lowest down of the Cumberland river furnaces, owned by G. D. Cobb and managed by C. C. Cobb of Dycusburg Crittenden county Kentucky, stands one and a half miles northeast of that town, was built in 1848, is 9 feet wide by 30 high inside, and made in 1855 about 1,300 tons of metal out of brown hematite ores from the neighborhood.

553. **Ozeoro,** once **Hopewell, Steam Cold-blast Charcoal Furnace,** owned and managed by Conner & Hughes, stands on the west side of the Cumberland river two miles west of Dycusburg, in Livingston county Kentucky, was built in 1847 and rebuilt in 1857, is like the last 9 by 30 inside, and made in thirty-three weeks of 1856 1,096 tons of metal out of the brown hematite ores of the neighborhood.

554. **Underwood Furnace** in Lyon county Kentucky, on the same side of the river as the last and three miles off southeast, was built by General White in 1846 and abandoned the same year.

555. **Suwannee Iron Works Steam Cold-blast Charcoal Furnace,** owned and managed by Wm. Kelly & Company, stands on the west fork of Poplar creek, two and a half miles back from Cumberland river and five miles west-northwest of

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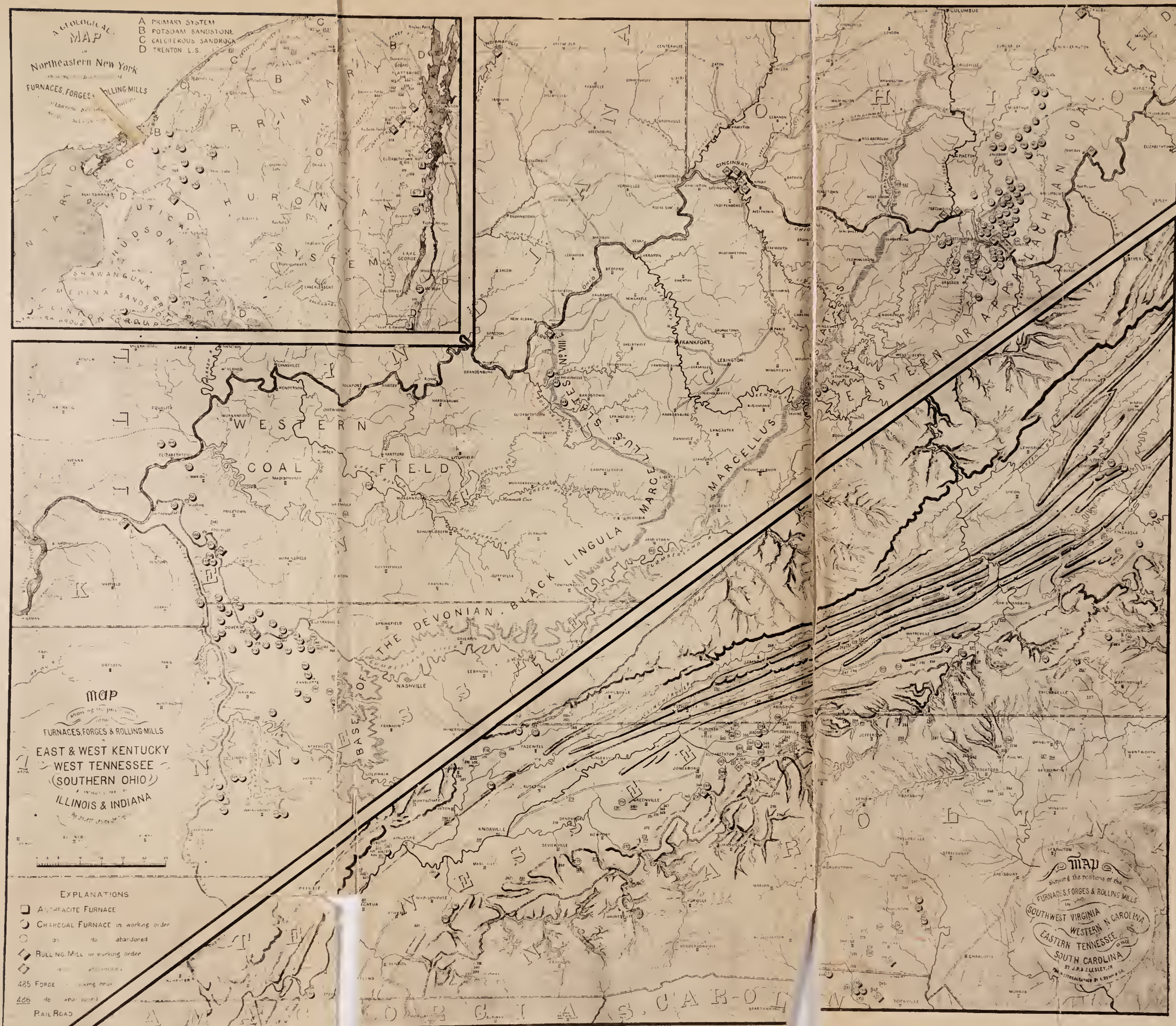

A GEOLOGICAL MAP of Northeastern New York
FURNACES, FORGES & ROLLING MILLS
A PRIMARY SYSTEM
B POTSDAM SANDSTONE
C CALCIFEROUS SANDROCK
D TRENTON L.S.
PRIMARY SYSTEM
HURON SYSTEM
HUDSON RIVER
UTICA SLATE
SHAWANGUNK
MEDINA SANDSTONE
ONTARIO
PLATTSBURG
LAKE GEORGE
MAP
FURNACES, FORGES & ROLLING MILLS
EAST & WEST KENTUCKY
WEST TENNESSEE
SOUTHERN OHIO
ILLINOIS & INDIANA
EXPLANATIONS
CHARCOAL FURNACE in working order
ROLLING MILL in working order
485 FORGE
RAIL ROAD
WESTERN COAL FIELD
BASE OF THE DEVONIAN BLACK LINGULA
MARCELLUS
Nº VIII
EASTERN OR APPALACHIAN COAL FIELD
INDIANAPOLIS
CINCINNATI
COLUMBUS
FRANKFORT
LEXINGTON
LOUISVILLE
EVANSVILLE
NASHVILLE
KNOXVILLE
ABINGDON
GREENVILLE
CHARLOTTE
MAP
showing the positions of the
FURNACES, FORGES & ROLLING MILLS
in
SOUTHWEST VIRGINIA
WESTERN N. CAROLINA
EASTERN TENNESSEE
and
SOUTH CAROLINA

Eddyville Lyon county Kentucky, was built the same year with Underwood Furnace last described (in 1846), is 10 feet wide by 35 feet high inside, and made in forty-four weeks of 1857 1,700 tons of metal adapted to the making of steel and used in Pittsburg for that purpose and in Cincinnati for making boiler plate out of brown hematite ore from the Iron Mountain bank three miles off to the west. During the last four years the metal has been converted into blooms at Union Forge and thence shipped by river to market. It is at this furnace that Mr. Kelly's process for refining iron in the hearth has been most fully experimented upon.

556. **An Old Furnace** two miles north of Eddyville built by Stacker & Watson in 1830 was dismantled in 1846.

557. **Mammoth Steam Cold-blast Charcoal Furnace,** owned by Graffenried & Co. and managed by J. L. James jun. Eddyville P.O. Lyon county Kentucky, stands one mile from the left bank of Cumberland river on Little Hurricane creek 5 miles south of Eddyville, was built by Charles Stacker in 1845, is 9 feet 2 inches wide across the top of the bosh by 31½ feet high inside, and made in forty-eight weeks of 1857 1,514 tons of metal out of brown hematite ore dug within three-quarters of a mile west of the furnace.

558. **Fulton Steam Hot and Cold-blast Charcoal Furnace,** owned and managed by Daniel Hillman of Empire Iron Works P.O. Trigg county Kentucky, stands in Lyon county eight miles south of Eddyville, three miles north of Empire Furnace and two miles west of the Tennessee Rolling Mill, was built in 1845 by Watson & Hillman, 11 by 33 inside, and made in twenty-two weeks of 1857 1,044 tons of metal for the rolling mill and for St. Louis and the Lower Mississippi markets, out of brown pot hematite ores from the immediate neighborhood. The hot blast has only been used since the spring of 1856.

559. **Centre Steam Cold-blast Charcoal Furnace,** owned by the same as Fulton Furnace last described, is eleven miles south of Eddyville and two and a half miles west of Empire Furnace (next below). It was built by the present owner in 1852 10 feet wide by 35 feet high inside, and made in forty-six weeks of 1856 2,139½ tons of metal.

560. Empire Steam Cold-blast Charcoal Furnace, owned by the same as the Fulton and Centre furnaces last described, stands on the left bank of the Cumberland River, one mile south of the Tennessee Rolling Mill and Forge and eleven miles from Eddyville; was built by T. T. Watson in 1843, and sold in 1849; is 9½ feet wide by 35 feet high inside, and made in forty-five weeks of 1856 1,836 tons of metal. The tunnel heads of Fulton, Centre and this furnace were all enlarged to 4 feet during April of this year, to prepare for the introduction of the patent conical-bottom filler now so successfully used at the Iron Mountain furnaces in Missouri.

561. Laura Steam Cold-blast Charcoal Furnace, owned by J. J. Tomlinson and managed by J. F. Gentry, Laura Furnace P.O. Trigg county Kentucky, stands two miles west of the Cumberland River, three miles north of Tennessee State line was built by Gentry, Gunn & Co. in 1855, 10 feet wide across the top of the bosh by 40 feet high, and made in forty-four weeks of 1857 1,637½ tons of iron out of brown hematite (mostly pot) ore from the neighborhood.

562. Lineport or Old Stacker Furnace, built by Stacker & Raybure in 1845, and abandoned in 1854, stands on the right bank of the Cumberland River near the State line, and is now owned by Lewis, Irvin & Co. of the Cumberland Iron Works in Stewart county Tennessee.

563. Gerard Steam Cold-blast Charcoal Furnace, owned by Bridge, Townley & Co. Mouth of Sandy P.O. Henry county Tennessee, stands in Calloway county Kentucky two miles west of the Tennessee River and one and a half mile north of the State line; was built by Browder, Kennedy & Co. in 1854, 10½ × 24, and made in thirty-four weeks of 1857 1,595 tons of iron for the St. Louis market out of brown hematite ore.

564. Saline Steam Cold-blast Charcoal Furnace, owned like Lineport Furnace No. 562, by Lewis, Irvin & Co. of the Cumberland Iron Works in Stewart county Tennessee, was built in 1853, two miles east of the Cumberland River, three from Lineport furnace and fourteen miles north by west from Dover court-house. It is 9 feet wide across the top of the bosh by 36 feet high, ran but one year and will never run again unless new and good ore banks be discovered in the neighborhood.

565. Great Western Steam Cold-blast Charcoal Furnace, owned by Newell and Pritchett of Clarksville, Mont-

gomery county Tennessee, stands in Stewart county near the State line, on the dividing ridge between the two great rivers and eighteen miles northwest of Dover court-house. It was built by Brian, Newell & Co. in 1854, is 10 feet wide by 40 high inside, and made in thirty-four weeks of 1855 about 1,350 tons of metal out of brown hematite ores of the neighborhood. Idle since in 1856.

566. Iron Mountain Steam Cold-blast Charcoal Furnace, owned by Ledbetter & Bostick (H. P. Bostick, Nashville, Tennessee), is twelve miles northwest of Dover court-house, Stewart county Tennessee, was built in the same year by the same parties as Great Western Furnace last described, 10½ feet wide by 42 feet high inside, made about 1,200 tons in thirty weeks in 1855 and nothing since. It used the pipe and pot brown hematite ore scattered over the surface, no permanent bank having been discovered yet.

567. Peytona Steam Cold-blast Charcoal Furnace, owned by Thomas Kirkman and managed by his son, is situated eight miles west-northwest of Dover court-house, Stewart county Tennessee, between the two rivers. It was built in 1847, rebuilt in 1856, is 9 feet wide inside by 42 feet high, and made in forty-six weeks of 1857 1,812 tons of metal for St. Louis out of brown hematite ores from beds a mile off north and south.

568. Clark Steam Cold-blast Charcoal Furnace, owned by Cobb, Phillips & Co. and managed by William Phillips, Standing Rock P.O. Stewart county Tennessee, is eight miles southwest of Dover court-house, on Leatherwood Creek, is 9½ feet wide across the top of the bosh and 34 feet high, and made in thirty-one weeks of 1856 perhaps 1,200 tons of iron out of brown hematite ore dug near the furnace. Out for two years.

569. Lagrange Steam Hot and Cold-blast Charcoal Furnace, owned by Cobb, Phillips & Co. managed by William Phillips, Standing Rock P.O. Stewart county Tennessee, and situated on Leatherwood Creek, one mile north from the Tennessee River, ten miles southwest of Dover court-house, was changed in January 1857 from hot to cold-blast, is 8 feet across the bosh by 36 feet high, and made in thirty-nine weeks of

1857 1,750 tons of iron out of brown hematite ore from banks two miles below.

570. Eclipse Steam Cold-blast Charcoal Furnace, owned by Cobb, Phillips & Co. managed by William Phillips, Standing Rock P.O. Stewart county Tennessee, and situated on Hurricane Creek, four miles north of the Tennessee River, twelve miles south by west of Dover court-house, is 9½ across the bosh by 35 feet high, and made in thirty-three weeks of 1855 1,291 tons of iron out of brown hematite ore from banks two miles off to the west.

571. Crosscreek Steam Cold-blast Charcoal Furnace, owned by Jordan, Brother & Co. Indian Mound P.O. Stewart county Tennessee, and situated seven miles north of the Cumberland Iron Works, was built in 1853, 10 feet across the bosh by 41 feet high and made in 1854 1,905 tons of iron for Valley Forge out of brown hematite ore close by.

572. Rough-and-ready Steam Cold-blast Charcoal Furnace, owned by Barksdale, Cook & Co. Indian Mound P.O. Stewart county Tennessee, and situated five miles northeast of the Cumberland Iron Works, was built in 1850 8 feet across the bosh by 30 high, and made in 1854 1,300 tons; has made nothing since 1856.

573. Bellwood Steam Cold-blast Charcoal Furnace, owned by Woods, Lewis & Co. managed by E. H. Lewis, Stewart county Tennessee, and situated half a mile back from the north bank of the Cumberland River, four miles north of the Cumberland Iron Works, is 9 feet wide across the bosh by 32 feet high and made in 1857 2,035 tons of iron out of brown hematite ore from the old Bear Spring bank, opened in 1829, a mile due west of the Cross Creeks' mouths.

574. Bear Spring Steam Cold-blast Charcoal Furnace, owned by Woods, Lewis & Co. Cumberland Iron Works P.O. Stewart county Tennessee, stands a ruin on the Clarksville and Dover road a mile northwest of the Cumberland Iron Works, is 9 by 28 inside, and made in 1854 962 tons of iron out of a rich ore close by. It was stopped in 1854 and its machinery removed to Dover No 2.

575. Dover No. 2 Steam Cold-blast Charcoal Furnace, owned by Woods, Lewis & Co. managed by John A. Irvin, Stewart county Tennessee, and situated on South Cross creek three miles southwest of the Cumberland Iron Works, was re-

built in 1854 9 feet across the bosh by 32 feet high and made in 1855 2,025 tons of iron out of brown hematite ore from the same bank as that mined for Bellwood Furnace 573.

576. Ashland Steam Coal-blast Charcoal Furnace, owned by G. P. Wilcox & Co. managed by G. P. Wilcox, Bowling Green, Cumberland county Tennessee, but situated in Stewart county and eight miles south by east of the Cumberland Iron Works and six miles southwest of Bowling Green, was built in 1851 with the dressed stones of the Van Buren stack (built by Brunsen more than twenty years ago), 9 by 35, and made in twenty-three weeks of 1857 1,150 tons of iron out of brown hematite ore found half a mile distant.

577. Union Steam Cold-blast Charcoal Furnace, owned by Robert McFall Palmyra P.O. Montgomery county Tennessee, stands in working order two miles south of the Cumberland river at Bowling Green, was built in 1853 9 feet across the bosh by 35 feet high and made in half of 1854 550 tons of iron, and nothing since for want of ore.

578. Blooming Grove Steam Cold-blast Charcoal Furnace, built by Dorsan Bailis in 1834, four miles north of Poplar Spring Furnace 579, one mile south of the Dover-Clarksville road was abandoned to ruin ten or twelve years ago.

579. Poplar Spring Steam Cold-blast Charcoal Furnace, owned by J. H. Jones & Co. managed by J. H. Jones, Clarksville P.O. Montgomery county Tennessee, and situated three miles north of the Cumberland river thirteen miles west by south of Clarksville, is 9½ feet wide across the bosh by 36½ feet high and made in 1855 1,300 tons of iron out of brown hematite ore lying around the works.

580. Yellow Creek Steam Cold-blast Charcoal Furnace, owned by R. Steel & Co. managed by J. McDonald and A. Brigham, Clarksville P.O. Montgomery county Tennessee, and situated fourteen miles southwest of Clarksville, was built in 1802, is 7 feet wide across the bosh by 31 feet high and made in thirty weeks of 1855 1,050 tons of iron out of brown hematite pipe ore.

581. Sailor's Rest Steam Cold-blast Charcoal Furnace, owned by Isaac D. West, managed by John Minor, Clarksville P.O. Montgomery county Tennessee, and situated fifteen miles southwest of Clarksville in the corner of the county, was built in 1854 8½ feet wide across the bosh by 37 feet high and made

in thirty-seven weeks of 1857 1,495 tons of iron out of brown hematite pipe ore one mile from the furnace and from the mouth of Yellow creek.

582. Montgomery Steam Cold-blast Charcoal Furnace, owned by Robertson, Russell & Co. managed by W. B. R. & J. Spence, Palmyra P.O. Montgomery county Tennessee, and situated twelve miles southwest of Clarksville and one and a half miles south of Palmyra P.O. is 9 feet wide across the bosh by 38 feet high, and made in thirty-five weeks of 1857 1,410 tons of iron out of brown hematite pipe and block ore within two miles of Palmyra.

583. Phœnix Steam Cold-blast Charcoal Furnace, owned by J. L. James Clarksville P.O. Montgomery county Tennessee, stands idle fourteen miles southwest of Clarksville, and made in 1854 1,500 tons of iron and nothing since.

584. Antonio O. K. Steam Cold-blast Charcoal Furnace, owned by Dixon, Vanleer & Co. managed by T. Y. Dixon Clarksville P.O. Montgomery county Tennessee, and situated on East Yellow creek six miles southeast of Palmyra and fifteen south-southwest of Clarksville, was burnt down and rebuilt about 1857 9 feet across the bosh by 34 high and made in thirty-nine weeks of 1855 1,340 tons of iron out of brown hematite ore around the furnace.

585. Louisa Steam Cold-blast Charcoal Furnace, owned by Jackson, McKiernan & Co. managed by Stephen D. Walker, Clarksville P.O. Montgomery county Tennessee, and situated seven miles south of the Cumberland river and twelve miles south of Clarksville, is 9 feet across the bosh by 33 feet high, and made in forty-six weeks of 1855 2,034 tons of iron for the neighboring forge out of brown hematite ore from a bank six hundred yards towards the west.

586. Washington Steam Cold-blast Charcoal Furnace, owned by Dr. Holmes was built by S. & J. Stacker on the old Charlotte-Clarksville county road in Montgomery county Tennessee, four miles north-northwest from Lafayette Furnace 588, and 9 miles south of Clarksville, and was abandoned twenty years ago and is in ruins.

587. Mount Vernon Steam Cold-blast Charcoal Furnace, owned by Jackson, McKiernan & Co. was built about 1838 by Baxter & Co. in Montgomery county Tennessee, four miles north-northwest of Louisa Furnace 585, and twelve miles south of Clarksville, a double stack which ran but one year, was abandoned and is in ruins.

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588. **Lafayette Steam Cold-blast Charcoal Furnace**, owned by Oliver Tinsley, was probably built by Samuel Stacker, on the same road as Washington Furnace 586, and two miles north of Tennessee Furnace 589, and three northeast of Louisa Furnace 585, and was abandoned by William M. Stewart many years ago and is in ruins.

589. **Tennessee Steam Cold-blast Charcoal Furnace**, owned by Jackson, McKiernan & Co. stands an abandoned stack one mile west of Water Forge, five miles northwest of Steam Forge, in Montgomery county Tennessee ; it was abandoned in 1851.

590. **Cumberland Steam Cold-blast Charcoal Furnace**, owned by Anthony W. Vanleer, managed by Hugh Kirkman, Charlotte P.O. Dickson county Tennessee, and situated on Iron fork of Barton's creek seven miles north by west of Charlotte, was built about 1790, is 9½ feet across the bosh by 29 feet high, and made in 1857 1,831 tons of foundry metal out of brown hematite ore within a mile or two.

591. **Carroll Steam Cold-blast Charcoal Furnace**, owned by William C. Napier, managed by William Thomas, Clarksville P.O. Dickson county Tennessee, and situated on a branch of Barton's creek three miles northwest of Charlotte, was rebuilt in 1853 8 feet across the bosh by 30 high and made in forty-two weeks of 1857 984 tons of iron out of brown hematite ore from three miles west.

592. **Bellevue, formerly Mammoth, Steam Cold-blast Charcoal Furnace**, built about 1825 by Montgomery Bell, on Jones' creek, three miles south of Charlotte, 11 feet bosh by 45 feet high, ran until after 1834 and was then abandoned for want of charcoal and ore at hand, and has now disappeared.

593. **Worley Steam Cold-blast Charcoal Furnace**, owned by James L. Bell, managed by J. M. Skelton, Clarksville P.O. Dickson county Tennessee, and situated ten miles south of west of Charlotte, was built in 1844, rebuilt in 1854, 8½ feet across the bosh by 36½ feet high and made in forty weeks of 1857 about 1,200 tons of iron out of brown hematite ore from banks three hundred yards distant.

594. **Piney Steam Cold-blast Charcoal Furnace**, owned by William H. Crutcher of Nashville, and situated nine miles south of Charlotte in Dickson county Tennessee, was built in 1832, is 9 feet across the bosh by 35 feet high and made in 1854 1,731 tons of iron out of brown hematite ore, three miles off.

595. **Laurel Steam Cold-blast Charcoal Furnace**, owned by William H. Crutcher like the last, and situated six miles southeast of Charlotte in Dickson

county Tennessee, was built in 1815, rebuilt in 1854 9 feet across the bosh by 28 feet high, and made in forty weeks of 1855 657 tons of iron out of brown hematite ore half a mile off. The furnace is abandoned and a camp-meeting pulpit erected in the run out arch.

596. Jackson Water Cold-blast Charcoal Furnace, owned by the Jackson Furnace Company Charlotte P.O. Dickson county Tennessee, stands idle twelve miles east of Worley Furnace 593, and fourteen southeast of Charlotte, was built in 1833, is 10 feet across the bosh by 47 feet high, and made in 1854 50 tons of iron and nothing since, and it will probably never make iron again.

597. Oakland Steam Cold-blast Charcoal Furnace, owned by Easley and Carothers, managed by P. N. Maroony, Pinewood P.O. Hickman county Tennessee, and situated seven miles northwest of Centreville, was built in 1854 7 feet across the bosh by 30 high and made in about thirty-four weeks of 1856 about 1,200 tons of iron out of brown hematite ore from banks a mile to the south. A new stack will soon be built.

598. Ætna Steam Cold-blast Charcoal Furnace, owned by Goodrich, Fell & Hillman, managed by L. S. Goodrich, Hickman county Tennessee, stands idle six miles southwest of Centreville, was built in 1846, is 9½ feet across the bosh by 30 high and made in thirty-nine weeks of 1854 1,509 tons of iron out of brown honeycomb hematite ore.

599. Cedargrove Steam Hot-blast Charcoal Furnace, owned by William Bradley & Co. managed by William Bradley, Perryville P.O. Perry county Tennessee, and situated two miles east of Perryville, is 9 feet across the bosh by 30 high and made in thirty-nine weeks of 1857 1,250 tons of iron out of brown hematite ore from the vicinity.

600. Cedargrove 2 Steam Hot-blast Charcoal Furnace, owned and situated like the last, and run alternately with No. 1, is only 7½ feet across the bosh by 30 high.

601. Brownsport Steam Hot-blast Charcoal Furnace, owned by Dick and McClure, Decaturville P.O. Decatur county Tennessee, and situated six miles south of Perryville and three miles west of the Tennessee river, was built in 1848, 10½ feet across the bosh by 31 feet high and made in 1854 2,109 tons of iron out of brown hematite ore.

602. Decatur Steam Hot-blast Charcoal Furnace, owned by Golliday, Cheathem & Co. managed by G. W. Carter, Clifton P.O. Wayne county Tennessee, and situated in

Decatur county on the left bank of the Tennessee river six miles west of Clifton P.O. Wayne county, and fourteen miles south of Perryville, was built in 1854 9¾ feet across the bosh by 40 high, and made in forty-six weeks of 1856 1,976 tons of iron out of brown hematite ore from banks a mile or two towards the east.

603. Marion Steam Cold-blast Charcoal Furnace, owned by James E. Walker of Columbia and Samuel P. Walker of Memphis, and situated two miles southwest of Carrollsville in Hardin county Tennessee, is nine feet across the bosh by 30 high and made in half of 1854 915 tons of iron out of brown hematite ore.

604. Forty-eight 1 Steam Cold-blast Charcoal Furnace, owned by the Pointer Brothers, Waynesborough P.O. Wayne county Tennessee, and situated on Forty-eight-mile Creek, where it is crossed by the Central Columbia Memphis turnpike, twenty miles from Clifton on the Tennessee River and five miles east of Waynesborough, was built in 1846, 8 feet across the bosh by 27 feet high and made in connection with No. 2, in 1854 2,445 tons of iron out of brown hematite ore from banks two hundred yards distant.

605. Forty-eight 2 Steam Cold-blast Charcoal Furnace, owned and situated like the last, is of the same size, both built of brick, and to be torn down and replaced by a single stack, cold-blast, 10 feet across the bosh by 42 feet high, with a capacity of fifteen tons per day.

606. Pilotknob 1 Steam Cold-blast Charcoal Furnace, owned by Pilotknob Iron Company, John S. McCune President, Joseph S. Pease Secretary, office No. 34 North Commercial street St. Louis, managed by J. B. Bailey, Pilotknob P.O. Iron county Missouri, and situated on the north side of the Pilotknob, at the end of the railroad eighty-six miles south-southwest from St. Louis, was built in 1849, 9½ feet across the bosh by 45 feet high, and made in sixteen weeks of 1857 1,039 tons of iron out of specular ore.

607. Pilotknob 2 Steam Hot-blast Charcoal Furnace, owned and situated like the last, but built in 1855, 10 feet across

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the bosh by 45 feet high, and made in 29 weeks of 1857 3,134 tons of iron out of specular ore.

607.5. **An old Charcoal Furnace,** was once in operation in town 33, range 4 north, half-section 2, running on nearly vertical veins of specular ore.

608. **Iron Mountain 1 Steam Hot-blast Charcoal Furnace,** owned by the American Iron Mountain Company, James Harrison of St. Louis President, managed by John J. Scott, Iron Mountain P.O. St. Francis county Missouri, and situated at the southwest base of Little Iron Mountain on the railroad six miles from the Pilotknob Furnaces and eighty from St. Louis, was built in 1846, rebuilt in 1854, 9 feet across the bosh by 31 feet high, and made in forty-seven weeks of 1855 2,103 tons of iron out of magnetic ore. It was cold-blast until 1857.

609. **Iron Mountain 2 Steam Cold-blast Charcoal Furnace,** owned and situated like the last, was built in 1850, rebuilt in 1854, 9 feet across the bosh by 32½ feet high, and made in twenty-five weeks of 1857 1,922 tons of iron out of magnetic ore.

610. **Iron Mountain 3 Steam Hot-blast Charcoal Furnace,** owned and situated like the last, was built in 1854 9¼ feet across the bosh by 38 feet high and made in thirty-five weeks of 1856 4,202 tons of iron out of magnetic ore.

611. **Maramec Water Cold-blast Charcoal Furnace,** owned by T. James' heirs Chilicothe, Ohio, leased and managed by W. James, Maramec Iron Works P.O. Crawford county Missouri, and situated ninety miles west-southwest from St. Louis, was built in 1826, rebuilt in 1856, 9 feet across the bosh by 34 feet high and made in thirty-four weeks of 1854 1,213 tons of iron.

612. **Franklin or Moselle Steam Cold-blast Charcoal Furnace,** owned by Franklin Iron Mining Company, managed by T. W. Childs, Franklin county Missouri, and situated forty-five miles west-southwest of St. Louis, was built in 1846 9½ feet across the bosh by 38 feet high, and made in forty weeks of 1855 about 2,000 tons of iron out of brown hematite lower silurian ore on the Company's lands.

613. **Illinois Steam Hot and Cold-blast Charcoal Furnace,** owned by C. Wolfe & Co. Cincinnati, Ohio, managed by

C. Henninger, Elizabethtown, Hardin county Illinois, and situated four miles north-northwest of Elizabethtown, is 10 feet across the bosh by 35 feet high and made in about forty-four weeks of 1857 about 1,800 tons of iron out of peroxide of iron filling vertical fissures in limestone.

614. Martha Steam Hot and Cold-blast Charcoal Furnace, owned by the Saline Coal & Manufacturing Company, resident manager Charles Sellars, Elizabethtown P.O. Hardin county Illinois, and situated four miles north of Elizabethtown and two miles east of Illinois Furnace last described, was built in 1849 10 feet across the bosh by 40 high, and made about 700 tons of iron per annum out of the same ore as used by Illinois furnace last described.

615. Richland Steam Hot-blast Charcoal Furnace, owned by A. Downing & Co. Bloomfield P.O. Green county Indiana, and situated two miles back from White river on Richland creek, was built in 1844, is 10 feet across the bosh by 34 feet high and made in thirty weeks of 1857 about 1,000 tons of iron out of limestone ores mixed with some bog and block.

616. Indiana Steam Hot-blast Charcoal Furnace, owned by E. M. Bruce & Co. managed by W. H. Watson, Vermilion county Indiana, and situated six miles from Sandford street Terre-Haute and Alton railway station, a few miles northwest from Terre-Haute, was built in 1839, is 10 feet across the bosh by 40 high and has made about 1,000 tons per annum out of brown hematite ore from the outcrop of a limestone bed among the coal measures.

616.4. Laporte (?) Charcoal Furnace near Laporte, in northern Indiana, was built perhaps in 1848, used bog ore and now stands idle.

616.5. Mishawaka Charcoal Furnace at Mishawaka, St. Joseph county Indiana was erected about 1833, has always done a fair business and is still running on bog ore.

616.6. Elkhart (?) Charcoal Furnace, in Elkhart county northern Indiana used bog ore.

617. Kalamazoo Hot-blast Charcoal Furnace, owned by W. Burtt & Son and managed by the same, Kalamazoo P.O. Kalamazoo county Michigan, stands at the junction of Kalamazoo river with a small stream one mile north of the village, was

rebuilt in 1857 $8\frac{1}{2}$ feet across the bosh by 31 feet high and made in half of 1857 about 1,000 tons of iron out of bog ore dug half a mile to the west across the river.

618. Quincy Steam Cold-blast Charcoal Furnace, owned by the Southern Michigan Iron Company, W. J. Briggs and Enos G. Berry owners and managers, Branch county Michigan, and situated three miles north of Quincy, was built in 1855 $8\frac{1}{2}$ feet across the bosh by 28 feet high and made in twenty-one weeks of 1857 450 tons of iron out of bog ore.

619. Branch County Steam Charcoal Furnace, owned by the Branch County Iron Company, N. B. Gale lessee and manager, Quincy P.O. Branch county Michigan, and situated in Butler township four miles north of Quincy, was built in 1854, and made in perhaps twenty-two weeks of 1857 perhaps 500 tons of iron out of bog ore.

620. Eureka Steam Hot-blast Charcoal Furnace, owned by the Eureka Iron Company, office at the foot of Third street in Detroit, J. S. Vanalstyne agent at the works, Wayne county Michigan, and situated ten miles south-southwest of Detroit in the village of Wyandotte on the right bank of the Detroit, was built in 1855 9 feet across the bosh by 34 feet high and made in twenty-three weeks of 1857 1,128 tons of iron out of Lake Superior magnetic ore, stamped and roasted at the furnace.

621. Detroit Steam Hot-blast Charcoal Furnace, owned by the Detroit and Lake Superior Iron Manufacturing Company, A. A. Rabineau secretary, situated at the east end of the city of Detroit in Wayne county Michigan, was built in 1857, rebuilt in 1858, 9 feet across the bosh by 42 feet high and made in ten weeks about 600 tons of iron from Lake Superior magnetic ore.

622. Pioneer 1 Steam Hot-blast Charcoal Furnace, owned by the Pioneer Iron Company, Charles T. Harvey agent at Marquette, L. T. Merrill treasurer, 189 Broadway New York, and situated sixteen miles west-southwest of Marquette, Marquette county Michigan, at the foot of the Jackson iron hill, was built in 1858 9 feet across the bosh by 42 feet high and has made 12 tons of iron per day out of red hematite from Jackson Mountain and specular ore.

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623. Pioneer 2 Steam Hot-blast Charcoal Furnace, owned and situated like the last, of the same size and capacity, is building in 1858 to run the same metal from the same ores.

624. Northwestern Charcoal Furnace, owned by the Northwestern Iron Company managed by F. Wilkes, Mayville P.O. Dodge county Wisconsin, and situated forty miles northwest of Milwaukee, five miles from the Iron Ridge, was built in 1853, and made in 1857 1,614 tons of iron out of Upper Silurian red hematite of the Clinton group Formation V. not fossiliferous as it is in the eastern states, but oölitic and silicious.

625. Ironton Charcoal Furnace, owned and managed by Jonas Tower, Ironton P.O. Sauk county Wisconsin, and situated in the town of Marston, Sec. 4, T. 12, R. 3 E. twenty-four miles west of Baraboa village, was built in 1857 7½ feet across the bosh by 30 feet high with a capacity of about 3 tons per day, and made in Jan. and Feb. of 1858 64¼ tons of foundry metal out of Potsdam Sandstone or Lower Silurian brown hematite ore.

626. Black River Charcoal Furnace, built by a German company, on the east bank of the Black River near its falls, four miles from flat-boat navigation to the Mississippi and on the location line of the Land Grant branch of the La Crosse railroad, was built to run upon azoic or primary ores, magnetic black oxide and red oxide mixed.

626.5. Adirondack Charcoal Furnace A, owned by the Adirondack Iron and Steel Company, managed by J. R. Thompson, and situated on Sanford lake and Adirondack river, fifty miles from water navigation and eight miles from the Sacketts Harbor and Saratoga railroad location line in New York State, was built with the other works in 1827 or '8, but has made very little iron, out of magnetic ore from the celebrated open quarry on the hillside above the lake.

626.6. Adirondack Charcoal Furnace B was added to the works in 1854, 11½ feet wide across the bosh by 48 feet high, capacity 14 tons per day, but has made no iron.

627. Mount Hope Hot-blast Charcoal Furnace, owned by B. F. Woodruff, Fort Ann P.O. Washington county New

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York, and situated eight miles northwest of Fort Ann village on a small stream three miles southwest of South Bay, was built in 1836, is 10½ feet across the bosh by 42 feet high and made in 1854 1,820 tons of iron out of magnetic ore from the Cheever mine in Moriah township and also from the neighborhood.

628. Crown Point Steam Hot-blast Charcoal Furnace, managed by E. S. Bogue, Crown Point P.O. Essex county New York, and situated ten miles west of Crown Point village, near Paradox creek and the east township line of Scroon, was built in 1845 11 feet across the bosh by 43 feet high, and made in 1857 3,430 tons of iron out of magnetic ore from the Scroon and Penfield mines one mile distant from the furnace towards the west.

629. Danemora Steam Hot-blast Charcoal Furnace, owned by the State of New York and situated in the State Prison inclosure at Danemora in Clinton county New York, was built in 1854, 13 (?) feet across the bosh by 41' feet high, and made in thirty weeks of 1855 1,440 tons of iron out of magnetic ore mined within the inclosure. (*Now abandoned.*)

630. Brasher Hot-blast Charcoal Furnace, owned by Isaac W. Skinner, Ogdensburg St. Lawrence county New York, and situated on the west bank of Deer river eight miles northeast of Brasher's Falls railroad station, and three miles southeast of Helena, was built in 1835, is 8 feet across the bosh by 29 feet high, and made in half of 1855 perhaps 400 tons of foundry iron out of bog ore close by.

630.4. Duane Charcoal Furnace, in Duane township, Franklin county New York, has been out ten years and is in ruins.

630.6. Cantonfalls Charcoal Furnace, owned by H. Van Rensselaer, and situated south of Canton St. Lawrence county New York, has been out of blast eight years and is in ruins.

631. Rossie Hot-blast Charcoal Furnace, owned by George Parish of Ogdensburg, managed by C. L. Lum, Rossie P.O. St. Lawrence county New York and situated in the village of Rossie on the north bank of Indian River, fourteen miles north of the Antwerp railroad station, was built about 1808, rebuilt in 1844, 11 feet across the bosh by 43 feet high, and made in half of 1854 1,962 tons of iron out of red oxide ore or true

hematite, from the Kean and Caledonia mines both near the railroad and twelve miles distant to the southeast.

632. Redwood Hot-blast Charcoal Furnace, managed by S. C. Sardan, Redwood P.O. Jefferson county New York, and situated two miles east of Redwood P.O. and at the outlet of Millsite lake, eight miles directly southwest from Rossie and eight southeast of its shipping port on the St. Lawrence, was built in 1849 (?) rebuilt in 1857 8½ feet across the bosh by 30 high and made in fourteen weeks of 1857 568 tons of iron out of red hematite from Kean's mine.

633. Wegatchie Cold-blast Charcoal Furnace, managed by A. P. Sterling, Antwerp P.O. Jefferson county New York, and situated on Oswegatchee river, three miles northeast of Oxbow and seven north of Antwerp, was built in 1846, 8 feet across the bosh by 36 feet high and made in forty-one weeks of 1856 1,107 tons of iron out of red hematite ore from the Sterling mine three miles distant towards the east and near the railroad, four miles north of Antwerp.

634. Fullerville Warm-blast Charcoal Furnace, owned and managed by Fuller & Peck, Fullerville Iron Works, St. Lawrence county New York and situated on the west bank of the west Oswegatchee branch, in the village of Fullerville, built in 1833, rebuilt in 1846, 8½ feet across the bosh by 33 feet high, made in about twenty-four weeks of 1856 about 700 tons of iron out of red hematite ore from the Kearney and Little York mines, mixed with magnetic ore from Clifton mine twenty-five miles distant.

635. Sterlingburg Cold-blast Charcoal Furnace, managed by A. P. Sterling, Antwerp P.O. Jefferson county New York and situated on the south bank of Indian river one mile east of Antwerp, was built in 1846, 9 feet across the bosh by 33 feet high and made in thirty-eight weeks of 1854 1,222 tons of iron out of red hematite ore from the Sterling mine. The forge once occupied this site.

636. Sterlingbush Cold-blast Charcoal Furnace, owned and managed by James Sterling, Sterlingville P.O. Jefferson county New York, but situated in Diana township Lewis county

twelve miles south-southwest of Antwerp, on the west bank of Indian river, built in 1848, 9 feet across the bosh by 33 feet high and made in forty-two weeks of 1855 1,322 tons of iron out of red hematite ore from the Sterling mine. An old furnace once occupied this site.

637. Sterlingville Cold-blast Charcoal Furnace, owned and managed by James Sterling, Sterlingville P.O. Jefferson county New York and situated in the village, on Black creek three miles above its entrance into Indian river, built in 1837, rebuilt in 1857, 9 feet across the bosh by 33 feet high, and made in half of 1855 700 tons of iron out of red hematite ore from the Sterling mine.

637.5. Carthage Charcoal Furnace in that village, Jefferson county New York, owned by the Antwerp Iron Company, P. S. Stewart local agent, Henry Nichol general agent, 24 William street New York city, was built about 1818, and has stood idle for ten years and is in ruins.

638. Alpina Hot-blast Charcoal Furnace, owned and managed by Z. H. Benton, Oxbow P.O. Jefferson county New York, and situated sixteen miles southeast of Antwerp on the outlet of Boney lake, two miles above its entrance into Indian river, was built in 1846, 9 feet across the bosh by 30 feet high, and made in twenty-three weeks of 1855 1,218 tons of iron out of red hematite ore from Kearney or Indian lake mine, mixed with black magnetic from the Jayville bed seven miles northeast.

639. Taburg Hot-blast Charcoal Furnace, managed by E. B. Armstrong, Rome P.O. Oneida county New York and situated in the village, on Fish Creek, near the line of the Rome and Watertown railroad eleven miles northwest from Rome, was built in 1810, rebuilt in 1832, is 9 feet across the bosh by 33 feet high, and made in forty-eight weeks of 1855 1,800 tons of iron out of Upper Silurian red hematite fossil ore of the Clinton group, Formation V. brought from southwest of Utica.

640. Constantia Hot-blast Charcoal Furnace, owned by William A. Judson, agent and manager, Syracuse P.O. Oswego county New York and situated on the north shore of Oneida lake, in the village of Constantia, twenty miles east of north from Syracuse, is 9 feet across the bosh by 35 feet high, and made in 1856 perhaps 1,800 tons of iron out of Upper Silu-

rian red fossil ore of the Clinton group, Formation V. mined southwest of Utica along its northern outcrop.

641. Norwich A. Steam Hot-blast Charcoal Furnace, owned by Reed, Haynes & Co. Norwich, Chenango county New York and situated in the town of Norwich on the Chenango canal midway between Utica and Binghampton, forty miles from each, was built in 1856, 9 feet across the bosh by 32 feet high and made in thirty-four weeks of 1857 1,228 tons of iron out of Upper Silurian red fossil Clinton ore, Formation V. mined in Oneida county.

642. Norwich B. Steam Hot-blast Charcoal Furnace, owned by Andrews, Rider & Co. B. B. Andrews agent Norwich Chenango county New York, and situated beside the last, was built in 1856, 9½ feet across the bosh by 30 high and made in 1857 2,016 tons of iron out of the same ore.

643. Wolcott Hot-blast Charcoal Furnace, owned by Leavenworth, Hendrick & Co. Wolcott P.O. Wayne county New York and situated on Wolcott creek, two miles north of the village, was built in 1821, rebuilt in 1846, 9 feet across the bosh by 35 feet high, and made in fifteen weeks of 1857 396 tons of iron out of Upper Silurian red fossil ore of the Clinton group Formation V. mined at its northern outcrop five miles off northeast.

644. Ontario Water and Steam Hot-blast Charcoal Furnace, owned by J. M. French & Co. A. J. Rixby agent Rochester, Wayne county New York and situated on the west bank of Bear creek, two miles north of Ontario Centre and south of the lake shore, and twenty miles north of east from Rochester, was built about 1825, rebuilt in 1847, 8 feet across the bosh by 30 high and made in thirty-eight weeks of 1857 1,004 tons of iron out of the same ore as the last described mined two miles off southwest.

645. Clinton Steam Hot-blast Charcoal Furnace, George B. Harris late superintendent, Ontario P.O. Wayne county New York, situated two miles southwest of Ontario Furnace last described, was built in 1848 9½ feet across the bosh by 35 feet high, and made in thirty-four weeks of 1857 1,250 tons of iron out of Upper Silurian red fossil ore of the Clinton group, For-

mation V. mined close by, here at its northern outcrop rising from under the Alleghany mountains.

646. L'Ilet Cold-blast Charcoal Furnace, owned by Du Puis, Robichon & Co. Three Rivers, Champlain county Canada East, and situated three miles from Saint Maurice Furnace 648, on l'Ilet rivulet two miles above its entrance into St. Maurice river, was built in 1857, 5 feet across the bosh by 30 high, and was to have made iron in 1858 out of bog ore dug near the furnace.

647. Radnor Cold-blast Charcoal Furnace, owned by A. Larue & Co. Three Rivers Champlain county Canada East, and situated twelve miles east of north from Trois Rivières, on Rivière au Lard, above the mouth of the river Champlain, was built in 1853 6½ feet across the bosh by 25 feet high, and made in 1856 1,176 tons of foundry iron out of bog ore dug in the vicinity.

648. Saint Maurice Cold-blast Charcoal Furnace, owned by Porter & Stewart, managed by James C. Sinton Three Rivers, Canada East, and situated in Saint Maurice county, seven miles north from Trois Rivières, at the mouth of a little stream entering St. Maurice river, was built about 1717, rebuilt 1855, 6½ feet across the bosh by 21 feet high, and made in thirty weeks of 1856 650 tons of carwheel iron out of bog ore mined at various places in the neighborhood. A furnace is said to have been run here by the Jesuits one hundred and forty years ago.

649. Marmora Hot-blast Charcoal Furnace, owned by the Marmora Iron Company, managed by William C. Evans, Marmora P.O. Hastings county Canada West and situated twenty-five miles northwest from Belleville, was built in 1856 11 feet across the bosh by 42 feet high, and makes iron out of black magnetic oxide from mines five miles distant.

650. A Furnace in New Brunswick. See Whitney's "Metallic Wealth," p. 458.

TABLES C. F. I.

BLOOMERIES AND FORGES IN THE UNITED STATES.

1. Nashua Forge, situated on the railroad to Lowell, below the Nashua depot and in sight of it, owned by the Nashua Iron Company, John H. Gage agent, Nashua, Hillsborough county New Hampshire, was built in 1848, has 9 heating furnaces, 12 forge fires and 6 hammers driven by steam, and made in 1854 825 tons of railroad axles, out of scrap with some old rails and foreign iron. The manufacture of wrought iron driving-wheels has been successfully commenced here for the first time in America.

2. Westford Forge, situated at Forge Village on the Stony Brook railroad, seven miles from Lowell towards Groton, James Prescott superintendent, at Forge Village, Middlesex county Massachusetts, Mr. Ainsworth treasurer of the company, George Stark agent, was rebuilt and enlarged in 1854 to contain 3 heating furnaces, 2 forge fires and 3 hammers driven by water, and makes anchor palms and carriage axles.

2.5. Alger's Forge, in South Boston, Suffolk county Massachusetts, owned by Alger and others, managed by E. Reed, has 2 heating furnaces, 1 train of rolls and 4 hammers and made in 1856 800 tons of forgings.

3. Commercial Point Forge, situated four miles southeast of Boston, on Commercial Point, Dorchester, a furlong east of the Old Colony railroad, in Suffolk county Massachusetts, owned by Dearborn, Robinson & Co. and managed by Thomas Loudon, was built in 1848, has one charcoal or bloomery fire, 6 forge fires, and 5 hammers driven by steam, and made in 1855 about 1,450 tons of axles, steamboat cranks, etc.

4. Holmes' Anchor Forges, situated: No. 1, in Kingston, one mile southwest of Kingston Depot on the Old Colony railroad, two miles above the mouth of the Jones river, and one mile above tide, in Plymouth county Massachusetts, owned

by Alexander Holmes of Kingston, and managed by George Holmes, was erected in 1792 as an edge-tool factory and turned to an anchor forge in 1800, has 1 charcoal fire, 4 forge fires and 2 hammers driven by water and makes about 140 tons of anchors etc. per annum.

5. **Holmes' Anchor Forge** No. 2, situated three miles northwest from No. 1, on the north side of the Old Colony railroad, three-quarters of a mile from Plympton station. It is the oldest works in the country, erected 100 years ago, and was first a forge for smelting iron ore taken in the form of bog ore out of Jones' pond, making poor iron, known at that day as Holmes' iron. It has 1 charcoal fire, 4 forge fires and 2 hammers driven by water, and makes about 60 tons of anchors etc. per annum.

5.5. **Bridgewater Forge and Rolling Mill,** Table D. 15, has 6 hammers.

6. **Talcott's Forge,** situated in Springfield three hundred yards east of the station, on the north side of the railroad to Worcester, owned by T. J. Talcott, Springfield Hampden county Massachusetts, has 1 heating furnace and 1 hammer driven by steam and makes perhaps 300 tons of axles and other heavy work per annum, out of scrap iron.

7. **Glastonbury Forge,** situated seven miles below Hartford on the east bank of the Connecticut river, in Hartford county Connecticut, owned and managed by S. S. Post, was an old forge, and then a rolling mill; now an anchor and bar works.

8. **Humphreysville Forge,** situated at Seymour, six miles above Derby, on the Naugatuck railroad in New Haven county Connecticut, owned by the Humphreysville Manufacturing Company, R. French president, Mr. Seymour manager, has 9 heating furnaces and 8 hammers, driven by water, and forges scrap iron into blooms and makes car axles.

8.5. **Ansonia Forge,** two miles above Derby on the Naugatuck railroad and river, was burnt and rebuilt in 1856 by the Novelty Company, has 2 heating furnaces, 2 forge hammers and 20 finishing forge hammers and makes perhaps 300 axes per day.

8.6. C. Wooster's Forge in Seymour, Connecticut, is about as large as the last described.

9. Ackworth Bloomery, situated in Lincoln, on New Haven river, thirteen miles from Vergennes city, Addison county Vermont, owned and managed by O. W. Burnham, was built in 1828, and enlarged 1843 and 1854, has 4 charcoal ore-fires and 2 hammers for drawing out the loups, driven by water, and made in 1856 550 tons of blooms.

10. White's Bloomery, situated on the railroad from Rutland, five miles above the mouth of Otter creek, in Addison county Vermont, is the only one running of all the old Vergennes bloomeries.

11. Salisbury Bloomery, in Addison county Vermont, owned by Israel Davey of Fairhaven, Rutland county, is old, has 2 fires and 1 hammer driven by water and makes about 300 tons of blooms per annum.

12. East Middlebury Bloomery, situated, owned, aged and equipped like the last, makes the same amount of blooms per annum.

13. Fairhaven Bloomery, in Rutland county Vermont, owned, aged and equipped like the two last, makes 400 tons of blooms per annum. All three use Lake Champlain magnetic ore from Essex county New York. See Rolling Mill No. 28 Table D.

14. Copake Forge, situated near the Copake Furnace near the Copake station on Harlem railroad Dutchess county New York, owned by Pomeroy & Company, was built in 1851, with 2 heating-furnaces and 5 hammers, driven by water, and made formerly gun iron, but latterly axles etc. out of scrap-iron, about 160 tons per annum.

15. Mount Riga Forges, situated near Mount Riga Furnace, Litchfield county Connecticut, owned by the Salisbury Iron Company and built in 1832, are scarcely ever in operation. Each forge has 1 puddling or chaffing fire, and 1 hammer for drawing bars and shafts, and 4 refining fires and 4 hammers, and 1 trip-hammer for small work, and together they made in 1856 perhaps 200 tons.

16. Ames' Forge, situated half a mile above Falls Village Station, Housatonic railroad, west side of the Housatonic River owned by the Ames Iron Company, Falls Village P.O. Salisbury Litchfield county Connecticut, was a small forge in 1832; the works have been principally enlarged in the last ten years, and consist of 2 double and 4 single puddling furnaces, 5 heating furnaces for piles and one for tyre, and 4 swedging fires, two Nasmyth hammers 5 and 2½ tons (6 and 3 with the dies on), and six heavy water-trip hammers, and makes axles, forgings of all kinds, connecting rods, etc. large shafts, car-axles and some bar-iron, in all about 800 tons per annum.

17. Canfield & Robbins' Forge, situated in Falls Village, Salisbury, in Litchfield county Connecticut, on the east side of the river, under the canal which was made some years ago to use the water of the high falls (70 feet) for a mile down the river and never finished, is owned by Canfield & Robbins, was built in 1832, has 2 heating furnaces 1 forge fire and 4 hammers, driven by water, and made in 1854 about 800 tons of axles, etc.

18. Salisbury Centre Forge, situated near the village of Salisbury Centre, Litchfield county Connecticut, two miles south from Chapenville Furnace, near the main road from Millerton to Hartford, and owned by S. B. Moore & Company, has 4 heating and refining fires and 2 large and 2 smaller hammers, driven by water-power, Mount Riga creek, and draws about 150 tons of pig iron into bars and shapes for government gun-works.

18.2. East Grove Forge, Lawrence, Norfolk, Connecticut.

18.4. New Hartford Forge, Connecticut.

18.6. B. N. Stephens Forge, West Norfolk, Connecticut.

18.8. Old Adams Forge etc. see note on page 151.

19. West Point Forge, situated at Cold Spring, on the Hudson River railroad, three miles above West Point Station, and half a mile from the Cold Spring Station, on the east side of the railroad, in Putnam county New York, Mr. Parrot agent, has 3 heating furnaces, 26 fires and 3 hammers, one of seven tons, and forges ordnance for the United States Go-

vernment and heavy steam-engine, steamboat and machine work.

20. **Franklin Forge,** situated near the East River, corner of Twenty-sixth street and First Avenue New York city, Tugnot, Dally & Co. has 6 heating furnaces, one Merrick & Towne hammer, 7 tons; two Nasmyth's, $2\frac{1}{2}$ and $1\frac{1}{2}$ tons, and one Kirk, and makes chiefly steam-engine heavy work, perhaps 300 tons per annum.

21. **Tupper's Forge,** at Sixteenth street, has been out for more than 18 months, and nothing remains there but a Merrick hammer of similar proportions to the Franklin's.

22. There is a new Forge on the North River, about Fifty-fourth street, just started by B. Danvers & Co. with one heavy hammer.

22. 5. **Haverstraw.**—Two abandoned forges stand on the creek back of Warren on the west bank of the Tappan Sea), Rockland county, New York.

23. **Suffern's.**—An old abandoned forge on the Maway at Suffern's, Rockland county, New York.

24. **Suffern's Forge and Rolling Mill,** situated a half mile west of Suffern's station Erie railroad, owned by Andrew Winter, Ramapo P.O. Rockland county New York, was built about 1849, as a bloomery with two fires and changed in 1853 to a rolling-mill, G 34, but has still 1 run out fire and 2 hammers, driven by water, and made car axles until 1856.

25. **Ramapo Iron and Steel Works,** situated opposite the New York & Erie railroad Ramapo station, Rockland county New York, owned by the heirs of Jeremiah G. Pierson, and leased by J. Wilson, was built about 1800, has 2 bloomery fires built in 1850 and a hammer, used for the steel works only. Table G, Rolling Mill 33.

25.2. **Sloat's Forge** and a forge above Sloat's, on the Ramapo River above the Ramapo Works, marked on the New Jersey map, but in ruins.

25.4. **Augusta Works.**—On the Ramapo, 3 miles above the Orange county line; a forge in ruins; not used for 50 years.

25.6. **Sterling Works.**—On the head-waters of the Pequest River; three marked on the map not now in existence.

There are said to be, besides those given in the table, the following forges in Litchfield county Connecticut: East Grove, Lawrence, Norfolk. New Hartford. N. B. Stephens's Forge, West Norfolk. Old Adams Forge, near Beckley Furnace (Tab. B. 15), owned by George Adams, and started by Mr. Forbes.

Table F

25.3 **Old Ringwood Forge.**—In the village of Ringwood, on the Pequest River, 1½ miles below the State, 3½ miles from Sloat's Station, E. R. R.; in ruins. Made its last iron about 1822.

26. **Ringwood Bloomery** six miles west of the New York and Erie railroad Sloat's station, at Boardville on the Pequest, owned by the Trenton Iron Company and managed by Philip R. George, Boardville P.O. Passaic county New Jersey, is very old and was built with Longpond Bloomery by Baron Hass before the Revolution, has 2 fires and 1 hammer, driven by water, and has made about 400 tons of blooms per annum, out of magnetic ore from mines one mile west of Ringwood.

26. **Long Pond Bloomery**, three miles northwest of the Ringwood Bloomery last described and owned and managed by the same, was built at the same time, has 4 fires and 2 hammers, driven by water, and makes about 800 tons of blooms per annum out of the same ore.

28. **Paterson Iron Works, a Forge** situated half a mile south of the station on the east side of the railroad, owned by the Paterson Iron Company, F. C. Beckwith treasurer, S. Jaqua superintendent, Paterson P.O. Passaic county New Jersey, was built in 1852, has 4 forge fires, 4 heating furnaces and 4 hammers, driven by steam, and made in 1854 378 tons of tyres and 520 tons of other forgings, out of some American blooms and 500 tons of English bar.

29. **Bloomingdale Bloomery** on the Pequannock river, five miles above Pompton and thirteen miles northwest of the New York and Erie railroad Paterson station, owned by Martin J. Ryerson, Bloomingdale P.O. Passaic county New Jersey, was built about 1800, rebuilt in 1839 and again in 1841, has 4 fires and 2 hammers, driven by water, and made in 1855 255 tons of bars and fagot iron for shafts and boiler plate, out of Ringwood ore.

29.5. **Freeland's Bloomery**, one mile above the last, has disappeared within a few years.

30. **Smith's Bloomery and Anchor Shop**, on the Pequannock river, sixteen miles northwest of the New York and Erie railroad Paterson station, three miles above Bloomingdale, owned by G. & T. Smith, Bloomingdale P.O. Passaic county New Jersey, was built a century ago, disappeared entirely and

was rebuilt in 1847, has 1 bloomery and 2 forge fires and 1 hammer, driven by water, and made in 1856 52 tons of anchors and bars, out of Ringwood and similar magnetic ores.

30.5. Two Forges, between Smith's and Charlottenburg, existed at the time the Loudon Company owned the Ringwood, Long Pond, Charlottenburg, and Mount Hope Works.

31. Charlottenburg Bloomery on the Pequannock river, in Passaic county New Jersey, nineteen miles northwest of the New York and Erie railroad Paterson station, eight miles above Bloomingdale, owned by George H. Renton of Newark, and managed by C. F. D'Camp, was built in 1840 on the site of an old furnace, has 4 bloomery and 2 forge fires, 2 hammers, is driven by water, and made in 1854, 300 tons of bar iron.

32. Turner's Anchor Forge, situated twenty-four miles northwest of the New York and Erie railroad Paterson station, owned by John Turner, Stockholm P.O. Passaic county New Jersey, and built about 1825, has 1 bloomery and 2 forge fires and 1 hammer, driven by water, and made in 1856 70 tons of anchors.

33. Stockholm Bloomery, situated twenty-five miles northwest of the New York and Erie railroad Paterson station, on the Pequannock river, owned by Horace Ford Stockholm P.O. Passaic county New Jersey, and built about 1790, has 1 fire and 1 hammer driven by water, and made in 1856 80 tons of blooms out of Ringwood magnetic ore.

34. Methodist Bloomery, situated on the Pequannock river, twenty-five miles northwest of the New York and Erie railroad Paterson station, owned by John Lewis, Stockholm P.O. Passaic county New Jersey, built about 1780 and rebuilt in 1850, has 1 fire and 1 hammer, driven by water, and made in 1856 80 tons of blooms, out of Ringwood magnetic ore.

35. Herring-bone Bloomery and Anchor Shop, situated on the Pequannock river in Passaic county New Jersey, twenty-five miles northwest of the New York and Erie railroad Paterson station, owned by James Ross of Newark and leased by J. Lewis, built about 1800 and rebuilt in 1857, has 2 forge fires and 2 hammers driven by water, and made in 1854 97 tons of anchors, out of Ringwood magnetic ore.

36. Windham Bloomery, half a mile above the last, owned by Edward Ford of Morristown, and leased by Edward Kincaid, built about 1790 and rebuilt in 1849, has 2 fires and 1 hammer driven by water and made in 1855 235 tons of blooms, out of Ringwood magnetic ore.

37. Stoney Brook Bloomery, situated on Stoney Brook, ten miles northeast of the Morris and Essex railroad, Rockaway station, seven miles due west of Pompton, owned by J. W. Earles, Bronton P.O. Morris county New Jersey, built about 1822 and rebuilt about 1849, has 1 fire and 1 hammer, driven by water and made in 1856 80 tons of blooms, out of Mount Hope, Hibernia and Ringwood magnetic ores.

38. Decker's Rockaway Valley Bloomery, situated on Stoney Brook, is six miles east-northeast of the Morris and Essex railroad, Rockaway station, three miles north of Powerville, owned by John and James Decker, Boonton P.O. Morris county New Jersey, and built about 1846, has 1 fire and 1 hammer, driven by water, and has made about 50 tons of blooms and bars per annum out of Hibernia and Mount Hope magnetic ores.

39. Dixon's Rockaway Valley Bloomery, situated on Middle Brook, five miles northeast of the Morris and Essex railroad, Rockaway station, one mile and a quarter north of Powerville, owned by William M. & Cyrus Dixon, Boonton P.O. Morris county New Jersey, built in 1827 and rebuilt about 1844, has 1 fire and 1 hammer, driven by water, and has made about 50 tons of bars per annum out of Allen and Hibernia magnetic ores.

40. Powerville Bloomery, situated in Powerville, four miles east of Rockaway station on the canal and river, owned by T. C. Willis, Boonton P.O. Morris county New Jersey, and built about 1853, has 2 bloomery and 2 forge fires and 1 hammer, driven by water, and has made about 200 tons of axle bars per annum, out of Hibernia magnetic ore.

41. Old Boonton Bloomery, situated on Rockaway river, six miles east of Rockaway, owned by Charles A. Richter, Boonton P.O. Morris county New Jersey, and built in 1853, has 2 fires and 1 hammer, and makes bars for the Dover Rolling

Mill out of Allen's magnetic ore. It was a slitting and rolling mill about 1790.

42. Troy Bloomery, situated on Parcipany river, six miles east-southeast of Rockaway, and eight miles northeast of Morristown, via Littleton and Parcipany, and owned by Smith & Cobb, Parcipany P.O. Morris county New Jersey, is as old as Oxford, has 1 fire and 1 hammer, driven by water, and has made about 40 tons of bars per annum out of Hibernia and Allen magnetic ores.

43. Durham Bloomery, situated at the head of Beaver brook, three miles south of Charlottenburg, and eight miles north-northeast of Rockaway station, owned by Crane's heirs, William Dixon administrator, Rockaway Valley Forge P.O. Morris county New Jersey, was built about 1811, has 1 fire and 1 hammer, driven by water, and made in 1856, about 60 tons of blooms out of Allen magnetic ore.

44. Splitrock Bloomery, situated at the foot of Beaver Lake, five miles north-northeast of Rockaway station, owned by Andrew B. Cobb, Parcipany P.O. Morris county New Jersey, was built about 1790, rebuilt about 1837, has 2 fires and 1 hammer, driven by water and made in 1856 perhaps 150 tons of slabs out of Lyonsville magnetic ore.

45. Stickel's Meriden Bloomery, situated on Beaver Brook, three miles south of Splitrock Bloomery last described and four miles northeast of Rockaway station is owned by Charles Stickel, Rockaway P.O. Morris county New Jersey, was built in 1790 and rebuilt in 1840, has 1 forge fire and 1 hammer, driven by water, and has made about 25 tons of bars and blooms per annum chiefly out of Allen's magnetic ore.

46. Richter's Meriden Bloomery, situated near Stickel's last described, and held by George E. Richter, executor, Rockaway P.O. Morris county New Jersey, was built in 1820, has 1 fire and 1 hammer, driven by water, and made in 1855 $88\frac{1}{2}$ tons of fagot bars out of Allen's and Mt. Hope magnetic ores.

47. Beach Glen Bloomery, situated on the west branch of Beaver run, two miles west by south of the Meriden forges,

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and three miles north of Rockaway railroad station, owned by C. & S. S. Black, Rockaway P.O. Morris county New Jersey, was built in 1760 and rebuilt in 1856, has 2 fires and 1 hammer, driven by water, and has made about 120 tons of blooms and bars per annum out of Hibernia, Beech's and Allen's magnetic ores.

48. Rockaway Steel Forge, situated at Rockaway Morris county New Jersey, on the Morris and Essex railroad, and owned by the Rockaway Iron and Steel Co. was built in 1805 and converted into a steel mill in 1855, has 5 converting fires, and 3 hammers, driven by water, and made in 1856 100 tons of cast steel out of iron and ore.

49. Bloomery Forge, situated at Rockaway, on the canal railroad and river, owned by S. B. Halsey, leased by Isaac H. Stickle, Morris county New Jersey, built about 1790 and rebuilt in 1857, has 2 fires and 1 hammer, driven by water, and made in 1854 180 tons of bars out of Allen's magnetic ore.

50. Denmark Anchor Bloomery, situated on the east fork of Burnt Meadow Brook, and seven miles north of Rockaway, via Mount Hope, owned by E. R. Biddle, 35 Wall street New York city, and leased by E. W. Temple, Berkshire Valley P.O. Morris county New Jersey, built about 1800 and rebuilt in 1853, has 1 forge fire and 1 hammer, driven by water, and has made perhaps 20 tons of anchors per annum, out of Mount Hope magnetic ore.

51. Middle Bloomery, situated down Burnt Meadow Brook one mile from Denmark furnace and six miles northwest of Rockaway, via Mount Hope, owned by George E. Richter, Rockaway P.O. Morris county New Jersey, built about 1810, rebuilt in 1848, has 2 fires and 1 hammer, is driven by water, and made in 1856 170 tons of bars out of Allen, Mount Hope and Mount Pleasant magnetic ores.

51.4. Ætna Forge, built about the time of the Revolution, stood within a few yards of the site of the Middle Bloomery last described, and was washed away before Middle Bloomery was built.

51.5. Mount Pleasant Forge, three miles from Dover and two miles below Berkshire Valley, belongs to Joseph Huff, has not run since 1850 and is nearly in ruins.

52. Washington Bloomery, situated five miles west of Rockaway, on the Morris and Essex railroad, is owned by Henry McFarlane, Dover P.O. Morris county New Jersey, was built about 1850 has 2 fires and 1 hammer driven by water, and made in 1856 141 tons of bars.

53. Valley Bloomery, situated on the Rockaway river, seven miles west of Rockaway station, owned by Jeremiah Baker and leased and managed by H. Baker, Dover P.O. Morris county New Jersey, was built about 1780, rebuilt in 1814 and again in 1828, has 1 fire and 1 hammer, driven by water, and made in 1855 32 tons of bars and blooms out of Saccasunna magnetic ore.

(Four forges are marked on the map above Valley Forge on the river, but none are known now to exist, until we get up to Lower Longwood. About three-quarters of a mile below it was a forge before Lower Longwood was built. No one knows of there having ever been forges at Berkshire Valley P.O.)

54. Lower Longwood Anchor Bloomery, situated four miles above Valley Forge, and three miles north of Berkshire valley P.O. Morris county New Jersey, on the turnpike, ten miles northwest of Rockaway, owned by C. McFarlan leased by E. W. Temple, built perhaps as long ago as 1800, has 2 forge fires and 1 hammer, driven by water, and made in 1856 85 tons of anchors out of Allen, Hopewell & Weldon magnetic ores.

55. Upper Longwood Anchor Bloomery, situated eleven miles northwest of Rockaway, viâ the turnpike, owned by C. O. Halsted of New York and leased by Nichols & Fichter, Berkshire valley P.O. Morris county New Jersey, and built perhaps as early as 1800, uses 2 of its 4 forge fires and 2 hammers, driven by water, and made in 1856 50 tons of anchors out of Allen magnetic ore.

56. Hard Bargain Bloomery, situated a half mile southeast of Petersburg, and thirteen miles north of Rockaway, owned by Stephen Strait, Millin P.O. Morris county New Jersey, and built in 1790, uses one of its 2 bloomery fires, has 1 hammer, driven by water, and made about 30 tons of blooms per annum mostly out of Allen magnetic ore.

57. Petersburg Bloomery, situated four miles north of Upper Longwood Furnace, and fourteen miles north of Rockaway,

viâ the turnpike, owned by Lewis Chamberlain, Milton P.O. Morris county New Jersey, and built in 1725, rebuilt in 1850, has 2 fires and 1 hammer, driven by water, and made in 1856 60 tons of bars out of Allen, Ringwood & Ogden magnetic ores.

58. Swedeland Bloomery, situated at the west end of Milton village in Morris county New Jersey, fifteen miles north of Rockaway, owned by Col. J. H. Stanborrough, and built in 1801, uses one of its 2 fires with 1 hammer, driven by water, and made in 1854 30 tons of blooms out of Ogden, Allen & Succasunna magnetic ores.

59. Russia Bloomery, situated two miles above Milton, seventeen miles north of Rockaway, owned by Frederic W. Fichter, Milton Morris county New Jersey, built about 1775, rebuilt in 1846 has 1 fire and 1 hammer, driven by water and made in 1856 35 tons of blooms out of Oakhill magnetic ore.

60. Hopewell Bloomery, situated eighteen miles north of Rockaway, viâ the turnpike, owned by John G. Harrison, Newfoundland P.O. Morris county New Jersey, built about 1780, rebuilt in 1830, has 2 fires and 1 hammer, driven by water, and has made about 100 tons of plate slabs out of Oakhill magnetic ore.

61. Canistear Bloomery, situated on the Pacack Brook, in Sussex county, three miles north of Stockholm, and twenty miles north of Rockaway, viâ Charlottenburg, Sussex county New Jersey, owned by Christian D. Day, Stockholm P.O. Morris county, built in 1796, rebuilt in 1832, has 1 fire and 1 hammer, driven by water and made in 1855 75 tons of blooms and bars, out of Ogden, Ringwood, Allen & Mount Hope magnetic ores.

62. Sparta (Decker's) Anchor Bloomery, one half mile below Sparta centre (on the Rockaway and Milford turnpike) fifteen miles northwest of Rockaway, owned by James & James L. Dicker, Sparta, Sussex county New Jersey, built in 1823, rebuilt in 1856, has 1 bloomery and 2 forge fires and 2 hammers, driven by water, and made in 1856 40 tons of anchors out of Ogden magnetic ore.

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63. **Eagle Anchor Blomery,** situated a little southeast of the village of Sparta, and fifteen miles northwest of Rockaway near the turnpike, owned by Lewis Sherman, Sparta, Sussex county New Jersey, built in 1821, rebuilt in 1838, has 1 bloomery and 3 forge fires and 2 hammers, driven by water and made in 1856 37 tons of anchors of magnetic ore.

64. **Morris Anchor Works,** No. 1, situated at the outlet of Norman's pond one mile east of Sparta, and sixteeen miles northwest of Rockaway, owned by Richard R. Morris, Sparta P. O. Sussex county New Jersey, has 2 forge fires and 1 hammer, driven by water, and together with Morris Anchor Works No. 2, made in 1856 90 tons of anchors.

65. **Morris Anchor Works,** No. 2, situated one mile below No. 1, on Byram's mill brook, owned by Richard R. Morris, Sparta Sussex county New Jersey, uses one of its 2 bloomery fires with 1 hammer, driven by water, and together with No. 1 made in 1856 90 tons of anchors, of magnetic ores.

66. **Columbia Anchor Bloomery,** situated on Lubber Run seven miles southwest of Sparta, and four miles north of Stanhope, owned by Sutton's heirs, leased by St. Lyon, Sparta P.O. Sussex county New Jersey, built about 1800; has 2 forge fires, 1 hammer, driven by water, and made in 1856 40 tons of anchors out of magnetic ore.

67. **Roseville Bloomery,** situated on Lubber Run, one mile south of Columbia Bloomery last described and owned by Rose & Byerley, Stanhope P.O. Sussex county New Jersey, built in 1828, uses one of its 2 bloomery fires with 1 hammer, driven by water, and made in 1856 64 tons of bars out of magnetic ore.

68. **Lockwood Bloomery,** situated on Lubber Run, three miles below Roseville Bloomery last described and one mile and a half northwest of Stanhope, owned by Joralemon & Howell, Stanhope P.O. Sussex county New Jersey, built in 1857, has 2 bloomery and 2 forge fires, with 2 hammers driven by water, and makes anchors out of Saccasuny magnetic ore.

69. **New Andover Bloomery,** situated on Musconetcong river one and a half mile from Waterloo Railroad station and one mile and a half west of Stanhope, owned by Gen. J. Smith,

Waterloo P.O. Sussex county New Jersey, built in 1804, rebuilt in 1857, uses one of its 2 fires with 1 hammer driven by water, and made in 1856 35 tons of blooms and bars, out of Dickerson magnetic ore.

70. Shippensport Bloomery on the canal, three miles east of Stanhope, and near Drakesville Morris and Essex railroad station, owned by John Slade of New York city, was built about 1843 and rebuilt in '47, uses 2 of its 4 bloomery fires with 1 hammer, driven by water, and made in 1856 60 tons of boiler blooms out of Hibernia and Byron blue magnetic ore.

71. Mount Olive Forge, situated three miles below the outlet of the South Branch Raritan river from Budd's Lake, and six miles south of Stanhope, owned by William Stephens, Drakestown P.O. Morris county New Jersey, has 1 fire and 1 hammer, driven by water, and made in 1856 70 tons of bars of all kinds.

72. Bartleyville Bloomery, the oldest in this neighborhood, situated one mile below Mount Olive last described and six miles south of Stanhope, Morris county New Jersey, owned by Gideon Salmon, Flanders P.O. built in 1790, rebuilt in 1849, uses one of its 2 bloomery fires and 1 forge fire, with 1 hammer, driven by water, and made in 1854 40 tons of rivet-bar, out of magnetic ore.

73. Welsh's (old Petersburg) Bloomery, situated one mile below Bartleyville, and six miles south of Stanhope, owned by Jacob S. Welsh's heirs, leased by H. Tice, Chester P.O. Morris county New Jersey, built in 1800, rebuilt in 1820 has 2 fires and 1 hammer, driven by water, and made in 1856 70 tons of bars and blooms out of Dickerson magnetic ore.

74. Budd's Bloomery, No. 1, situated on Black river, three miles southwest of Chester, and eleven miles south of Stanhope, owned by Daniel Budd and managed by R. Day, Chester P.O. Morris county New Jersey, built in 1850, rebuilt in 1856, has 2 bloomery and 1 forge fire with 1 hammer, driven by water, and made in 1856 190 tons of boiler blooms, out of Budd's magnetic ore.

75. Budd's Bloomery No. 2, situated three-quarters of a mile below No. 1, has the same owner and manager, 2 bloomery

and 1 forge fire with 1 hammer driven by water, and made in 1856 30 tons of bars and blooms, out of the same ore.

75.5. Bristol Forge, situated on the Delaware Division Canal, in the northern part of Bristol, Bucks county, Pennsylvania, owned by the Bristol Forge Company, managed by Herman L. Strong, was built about 1844, and has 3 hammers (one Nasmyth), and makes shafts, axles and forgings out of scrap iron altogether.

76. Oxford Steel and Iron Forge, situated in the twenty-third ward of Philadelphia, and owned by W. & H. Rowland (No. 61 South Second street), was built in 1842, has 4 heating furnaces, 2 hammers driven by steam, and made in 1856 626 tons of blooms.

77. Norris's Forge, situated in Philadelphia on 17th street above Callowhill, owned by Richard Norris & Son, and managed by M. Sevank, has 2 heating furnaces, 2 hammers, driven by steam, and made in 1856 600 tons of finished work.

78. Fairhill Forge, situated in Philadelphia, in the nineteenth ward, and owned by Patterson, Morgan & Caskey on the North Pennsylvania Railroad, above York road, was built in 1856, has 1 heating furnace and 2 hammers driven by steam, and made in 1856 127 tons of shafting.

79. Verree's Works, situated in Philadelphia, on the North Delaware Avenue, above Poplar street and owned by Verree & Mitchell, was built in 1856, has 2 heating furnaces and 1 hammer, driven by steam, and made in 1856 about 350 tons of scrap-blooms.

80. **Flat-Rock Forge,** situated in Manayunk, seven miles northwest of Philadelphia, owned by M. B. Buckley & Son, Manayunk, Philadelphia county, and built in 1850, has 6 forge fires and 1 hammer, is driven by steam and water, and made in 1856 about 700 tons of blooms. This Forge was torn down in the winter of 1857–8, and removed to the new Rolling Mill at Gray's Ferry, below Philadelphia. See Table G.

81. Pencoyd Forge, situated on the west side of Schuylkill, six miles northwest of Philadelphia, Montgomery county and half a mile below Manayunk, is owned by A. & P. Roberts, Philadelphia, was built in 1852, has 1 forge fire and 2 hammers, is driven by steam, and made in 1855 314 tons of axles and bars.

82. Green Lane Forge, situated on Perkiomen creek, twenty miles north of Morristown, owned by William Schall, Norristown, Montgomery county Pennsylvania, leased by Smith & Brother, managed by James Smith, built in 1733, has 3 forge fires and two hammers, is driven by water, and made in 1856 180 tons of blooms and bars.

83. Glasgow Forge, situated on the Manatawny creek, one mile north of Pottstown, owned by J. Rittenhouse, Pottstown P.O. Montgomery county Pennsylvania, and leased and managed by Joseph Potts, was built about 1750, uses 2 of its 3 forge fires and 2 hammers, is driven by water, and made in 1856 300 tons of blooms.

84. Mount Pleasant Forge (formerly Fish's), situated on the northwest branch of Perkiomen creek, fourteen miles north of Pottstown, is owned by Samuel W. Weiss, Colebrookdale, Washington township, Berks county Pennsylvania, was built in 1799, has 2 forge fires and 1 hammer, is driven by water, and made in 1856 50 tons of blooms and 63 tons of bars.

85. District Forge, No. 1, situated twenty miles east of Reading, and owned by Horace Trexler, Pike township, Berks county Pennsylvania, was built in 1797, has 2 forge fires and 1 hammer, is driven by water, and made in 1854 60 tons of blooms and 50 tons of bars.

86. District Forge, No. 2, situated on Pine creek, six miles north-northeast of Douglassville, owned by Francis Heilig, Laubachsville P.O. Berks county Pennsylvania, was built in 1800, has 2 forge fires and 1 hammer, is driven by water, and made in 1856 200 tons of blooms and 20 tons of bars.

87. Rockland Forge, No. 1, situated six miles southeast of Kutztown and owned by Mr. Malenshäffer, Laubachsville P.O. Berks county, was built in 1788, has 1 forge fire and 1 hammer, is driven by water, and made in 1854 75 tons of blooms.

88. Rockland Forge, No. 2, situated six miles southeast of Kutztown and owned by William Herbst, Laubachsville P.O. Rockland township, Berks county, was built in 1790, has 1 forge fire and 1 hammer, is driven by water, and made in 1855 300 tons of blooms.

89. Oley Forge, situated on Manatawny creek, two miles east of Friedensburg, and twelve miles east of Reading, and owned by Jacob S. Spang, Spangville Manatawny, Berks county Pennsylvania, was built in 1780, has 2 forge fires and 1 hammer, is driven by water, and made in 1856 perhaps 200 tons of blooms.

90. Spring Forge, situated on the Manatawny creek, five miles west by north of Douglassville, and owned by Bertolet & Darrah, Earl township, Berks county Pennsylvania, was built in 1795, has 2 forge fires and 1 hammer, is driven by water, and made in 1856 about 250 tons of blooms.

91. Dale Forge, situated in the Eisenthal or Iron Dale, on the stage road from Pottstown sixteen miles east of Reading, and owned by David Schall, Dale Forge P.O. Berks county Pennsylvania, was built in 1803, has 3 forge fires and 2 hammers, is driven by water and made in 1856 about 150 tons of bars chiefly.

92. Speedwell Forge, No. 1, situated two miles east of Reading, owned by David Yocum, Speedwell Forge P.O. Berks county Pennsylvania, was built in 1809, has 2 forge fires and 1 hammer, is driven by water, and made in 1856 about 25 tons of blooms and 100 tons of bars.

93. Speedwell Forge, No. 2, situated two miles east of Reading and owned by M. Yocum & Ströckh, Speedwell Forge P.O. Berks county Pennsylvania, was built in 1825, has 2 forge fires and 1 hammer, is driven by water, and made in 1856 about the same as No. 1.

94. Exeter Forge, situated on Antietam creek, four miles north of Birdsborough, five miles east of Reading, owned by Gottlieb Moyer & Daniel Yocum and managed by Daniel Yocum, Reading P.O. Berks county Pennsylvania, built in 1836, has 2 forge fires and 1 hammer, driven by water and made in 1856 251¼ tons of blooms.

95. Seidel's Forge, situated north of the Pike, and four miles east of Reading, owned by Himmelshütz & Seidel, leased and managed by S. C. Seidel, Reading P.O. Berks county Pennsylvania, was built in 1853, has 1 forge fire and 2 hammers, is driven by water and made in 1856 100 tons of scrap bars.

96. Keystone Forge and Rolling Mill, situated in Reading at the corner of Pine and Second streets, is owned by Snell, Mullen, Banford & McCarty, Reading Berks county, was built in 1854, has 2 heating furnaces and 2 hammers, is driven by steam, and made in 1856 350 tons of axles and shafts.

97. Reading Steam Forge, situated in Reading, Fosthockley Lane and Eighth street, owned by Reading Steam Forge Company, Reading Berks county, and managed by Wesley M. Lee, was built in 1857, has 3 puddling fires, 4 heating furnaces and 4 hammers, is driven by steam and made in 1856 say 1,000 tons of heavy forgings.

98. Franklin Forge (Old Rip Rap), situated on Alleghany creek, half a mile west of the Schuylkill, 5 miles east of Reading, owned by J. & H. Thompson, Robinson P.O. Berks county, built in 1837, has 2 forge fires and 1 hammer, driven by water and made in 1856 200 tons of flat blooms.

99. Gibraltar Forge, No. 1, situated six miles south of Reading, on Alleghany creek, quarter of a mile above the Rolling Mill, owned by H. A. & S. Seyfert of Reading, Berks county, built in 1846, has 2 forge fires and 1 hammer, driven by water, and in 1856 made 250 tons of blooms.

100. Gibraltar Forge, No. 2, situated six miles south of Reading on Alleghany creek, half a mile above the Rolling Mill, owned by H. A. & S. Seyfert of Reading, Berks county, has 3 forge fires and 1 hammer, driven by water, and in 1856 made 275 tons of blooms.

101. Do Well Forges, situated six miles south of Reading, on the small stream next south of Alleghany creek and quarter of a mile apart, owned by J. & J. B. Seidel and managed by Reuben Seidel, Reading Berks county, built in 1825, have 2 forge fires and 2 hammers, driven by water, and in 1856 made 200 tons of blooms and 120 of bars.

102. Coventry Forge, situated at Coventry Village, on Rock Run, six miles southwest of Pottstown, owned by George Christman, Pughtown, Chester county, leased to J. Bingham, built in 1750, has 3 forge fires and 1 hammer driven by water, and in 1855 made 352 tons of blooms.

103. Isabella Forge (formerly Furnace), situated sixteen miles south of Pottstown, and nine miles north of Coatesville on the waters of the West Branch Brandywine, owned by John Irey and James Butler, Loag P.O. Chester county, built in 1853, has 4 forge fires and 1 hammer driven by steam and water and in 1856 made 560 tons of blooms.

104. Springton Forge, situated seven miles north of Downingtown, on East (main) Branch of Brandywine, on the Wilmington-Reading State Road, owned by John Carnog and A. P. McIlvaine, Wallace P.O. Chester county, built in 1790, has 3 forge fires and 1 hammer driven by water, and in 1855 made 240 tons of blooms.

105. Mary Ann Forge, situated two miles north of Downingtown, on the North Branch Brandywine and five miles below Springtown, owned by William Dowlin, Downington P.O. Chester county, built in 1785, has 2 forge fires and 1 hammer driven by water and in 1855 made 155 tons of blooms.

106. Hibernia Forge (and Rolling Mill), situated four miles north of Coatesville on the West Brandywine, owned by Charles Brooke, Wagontown, Chester county, built in 1792, has 2 forge fires and 1 hammer driven by water, and in 1855 made 162 tons of blooms.

107. Greenwood Forge (formerly Furnace), situated one quarter of a mile north of Penningtonville, owned by George Buckley & Brothers, Penningtonville, Chester county, leased by Latta & Baker and managed by J. Lightfoot, built in 1844, has 4 forge fires and 1 hammer, and in 1856 made 196 tons of blooms.

108. **Pleasant Garden Forge (and Rolling Mill),** situated five miles southeast of Oxford on the Brandywine and two miles southwest of New London Cross Roads, owned by D. McConkey and James Painter, Westchester, Chester county, built in 1806, has 4 forge fires and 1 hammer, and made annually about 150 tons of boiler blooms. It is in ruins.

109. Poole Forge, situated twenty miles northeast of Lancaster, on Conestoga creek, west of Churchtown, owned by J. O. Blight, Churchtown P.O. Lancaster county, built about in 1760, rebuilt in 1833, has 1 forge fire and 1 hammer driven by water and in 1855 made 275 tons of blooms.

110. Windsor Forges, situated twenty miles northeast of Lancaster on Conestoga creek and one quarter of a mile south of Churchtown, owned by David Jenkins' Heirs, Windsor Furnace P.O. Lancaster county, and leased to Jacob Jamieson, built about in 1745 (swept away in 1822), has 4 forge fires and 2 hammers driven by water and in 1856 made say 350 tons of blooms.

111. Spring Grove Forge, situated twenty miles northeast of Lancaster, on Conestoga creek, three miles west of Poole Forge, owned by William Boyd Jacobs, Churchtown P.O. Lancaster county, built in 1793, has 3 forge fires and 2 hammers driven by water and in 1854 made 468 tons of blooms.

112. Brooke Forge, situated three miles northwest of Gap station, on Pequea creek one mile northwest of Pequea P.O. owned by G. W. Bulkley, Pequea P.O. Lancaster county, built in 1795, rebuilt 1820, has 3 forge fires and 1 hammer driven by water, and in 1856 made 15 tons of blooms and 50 of bars.

113. Sadsbury Forge, No. 1, situated two and a half miles from Penningtonville, on Octorara creek, owned by Charles N. Sproul, Ringwood P.O. Lancaster county, leased to C. Cloud, built in 1800, has 1 forge fire and 1 hammer driven by water, and makes annually in connection with Forge No. 2, about 250 tons of blooms.

114. Sadsbury Forge, No. 2, situated half a mile east of Sadsbury No. 1, on Octorara creek, owned by Charles N. Sproul, Ringwood P.O. Lancaster county, leased to C. Cloud, built in 1802, has 1 forge fire and 1 hammer driven by water and makes annually in connection with No. 1, about 250 tons of blooms.

115. Ringwood Forge, situated three miles from Penningtonville, on Octorara creek, owned by James Sproul's heirs, Ringwood Forge P.O. Lancaster county and leased to C. Cloud, built in 1810 and rebuilt 1854, has 3 forge fires and 1 hammer driven by water, and in 1856 made 234 tons of blooms.

116. Pinegrove Forge (and Rolling Mill), situated sixteen miles south of Penningtonsville, owned by Enos Pennock, Hopewell Cotton Works P.O. Lancaster county, built about 1800

and rebuilt in 1838, has 2 forge fires and 1 hammer driven by water, and in 1854 made 247 tons of blooms.

117. White Rock Forge, situated south of Penningtonville on the west branch of Octorara creek, and one and a half miles northeast of Oakshade Post-office, owned by James Sproul's heirs, Whiterock Forge P.O. Lancaster county, built in 1829, has 4 forge fires and 2 hammers driven by water, and in 1854 made 359 tons of blooms.

118. Octorara Forge (and Rolling Mill), situated eight miles north of Port Deposit, on Octorara creek, four miles above its mouth just inside the Maryland State Line, owned by Parke & Son Rising-Sun, Cecil county Maryland, built about in 1810, has 1 forge fire and 1 hammer driven by water, made annually 200 tons of blooms, and is to be abandoned.

119. Colemanville Forge (Rolling Mill and Steel Furnaces), situated twelve miles southwest of Lancaster, on the Pequea creek, fifteen miles south of Columbia, owned by G. D. Coleman, Colemansville, Lancaster county, managed by Maris Hoopes, built in 1828, has 4 forge fires and 1 hammer driven by water, and in 1856 made 633 tons of blooms.

120. Martic Forge (and Steel Furnace), situated three-quarters of a mile east of Colemansville, owned by George Steele, Colemansville Lancaster county, built in 1755 and rebuilt about 1842, has 4 forge fires and 2 (?) hammers driven by water and in 1856 made $562\frac{3}{4}$ tons of blooms.

121. Castlefin Forge and Rolling Mill, situated sixteen miles northwest of Port Deposit, and thirty miles from York, owned by R. W. & W. Coleman, Lebanon or Castlefin P.O. York county, managed by S. M. Reynolds, built in 1810 and rebuilt in 1827, has 3 forge fires and 1 hammer worked by water, and makes annually about 500 tons of blooms.

122. Woodstock Forge (and Foundry), situated five miles south of Wrightsville, on Cabin branch, one mile west of Tidewater Canal, owned by Himes & Hahn, Margaretta Furnace P.O. York county, and managed by Thomas Himes, built in 1828, has 5 forge fires and 2 hammers worked by water, and made in 1856 perhaps 600 tons of blooms and 100 tons of bars.

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123. Spring Forge, York county, built in 1770 had 2 forge fires and 2 hammers worked by water, and is now abandoned.

124. Baltimore Steam Forge (**and Bar Iron Rolling Mill**), situated in Baltimore, near Philadelphia railroad station owned by Fageley, Heird & Co. City Block, Baltimore, Maryland, built in 1856, has 1 heating fire and 2 hammers, one a Nasmyth's, worked by steam, and in 1856 made 280 tons of car axles.

125. Bushkill Forge, situated half a mile west of Easton, on the Bushkill creek, owned by Simple & Swinney, Easton, North Hampton county, has 1 forge fire and 1 hammer worked by water, and in 1856 made 125 tons of bars.

126. Maiden Creek Forge, situated five miles east of Hamburg, on Maiden creek, and twenty miles north of Reading and twenty-three miles west of Allentown, owned by George Merkle & Co. Leonardsville P.O. Berks county, managed by George Rimsel, built in 1828, has 2 forge fires and 1 hammer worked by steam, and in 1856 made perhaps 40 tons of bars.

127. Mount Airy Forge, situated ten miles west of Hamburg, on the Northkill creek, fourteen miles from Pottsville, owned by Joseph Seyfert, Mount Airy P.O. Berks county, managed by George Rimsel, built in 1840, has two forge fires and 1 hammer worked by water, and in 1856 made about 300 tons of blooms.

128. Northkill Forge, situated eight miles west of Hamburg, on the Northkill creek, and six miles north of Bernville, owned by Joseph Seyfert, Schartlesville P.O. Berks county, built in 1830, has 1 forge fire and 1 hammer worked by water and in 1854 made 150 tons of blooms.

129. Charming Forge, situated fifteen miles west of Reading on the Tulpehocken, and within two miles of Womelsdorf, owned by Andrew Taylor & Sons, Furnace P.O. Berks county, managed by William Taylor, built in 1849, has 3 forge fires and 2 hammers worked by water and in 1856 made 338 tons of blooms.

130. Lebanon Forge, situated in Lebanon, owned by Seidel Killinger & Co. Lebanon P.O. Lebanon county, built in 1857

was intended for a rolling mill, but for the present only hammers scrap blooms.

131. Union Forge, situated twelve miles north of Lebanon, on the Swatara river, within one hundred and fifty yards of the feeder of the Union Canal, owned by Jacob B. Weidman, Lebanon P.O. Lebanon county, built in 1845, has 5 forge fires and 2 hammers, worked by water, and in 1856 made 249 tons of blooms and 10 tons of bars.

132. Monroe Forge, situated twelve miles north of Lebanon, on Monroe creek, two miles from Swatara river, owned by Seidel Killinger & Co. Lebanon P.O. Lebanon county, built in 1836, has 4 forge fires and 1 hammer worked by water and in 1856 made 549 tons of blooms.

133. Newmarket Forge, situated twelve miles west of Lebanon, on Quitapihilla creek, two miles from Swatara river, owned by Jacob Light, leased and managed by Light and Early, Anville P.O. Lebanon county, built in 1795, has 4 forge fires and 2 hammers worked by water, and in 1855 made 354½ tons of blooms.

134. **Speedwell Forge,** situated eleven miles south of Lebanon, on Hammer creek and six miles from Litiz, owned by R. W. Coleman, Cornwall P.O. Lebanon county, built in 1750, has 3 forge fires and 1 hammer worked by water and in 1849 made 300 tons of blooms. It is now abandoned and in ruins.

135. Liberty Forge, situated seven miles southwest of Harrisburg on Yellow Breeches creek, three miles from Cumberland Valley railroad, owned by T. L. Boyer, Shiremanstown P.O. Cumberland county, built in 1790, has 4 forge fires and 2 hammers driven by water and in 1856 made 529 tons of blooms and 4 tons of bars.

136. Carlisle Forge, situated four and a half miles southeast of Carlisle on Boiling Springs and Yellow Breeches creek, owned by Peter F. Ege, Carlisle Cumberland county, managed by Jacob Goodyear, built in 1811, has 2 forge fires and 2 hammers worked by water and in 1855 made 271 tons of bars.

137. Laurel Forge (and Furnace), situated on Laurel creek, fourteen miles southwest of Carlisle, owned by William M. Watts, Carlisle Cumberland county, managed by Adam Shufler, built in 1830, rebuilt in 1845, has 2 forge fires, 4 run-

out fires and 2 hammers worked by water, made in 1856 415 tons of blooms and 13 tons of bars.

138. Big Pond Forge (and Furnace), situated sixteen miles west-southwest of Carlisle, and six miles southeast of Shippensburg, owned by Schoch, Sons & Co. Shippensburg P.O. Cumberland county, managed by Isaac S. Matthews, built in 1851, has 3 forge fires, 1 run-out fire and 1 heating fire and 1 hammer worked by water, and in 1856 made 243 tons of blooms.

139. Caledonia Forge, situated ten miles east of Chambersburg, on the Conecocheague creek, fifteen miles west of Gettysburg, owned by Thaddeus Stevens' heirs, Graffenburg P.O. Franklin county, managed by Henry Sloat, built in 1830, has 4 forge fires, 2 run-out fires and 3 hammers worked by water, and in 1855 made 370 tons of blooms and 150 tons of bars.

140. Mont Alto Forge, No. 1, situated thirteen miles southeast of Chambersburg, four miles southeast of Mont Alto Furnace, and near the Adams county line, owned by Holker Hughes, Palo Alto P.O. Franklin county, built in 1809, has 4 forge fires and 1 heating fire and 2 hammers worked by water and makes annually (in connection with Mont Alto, No. 2) about 300 tons of blooms and 200 tons of bars.

141. Mont Alto Forge, No. 2, situated thirteen miles southeast of Chambersburg, four miles southeast of Mont Alto Furnace, and near the Adams county line, owned by Holker Hughes, Palo Alto P.O. Franklin P.O. built in 1810 and rebuilt in 1842, has 5 forge fires, 1 run-out fire and 2 hammers worked by water, and makes annually (in connection with Mont Alto, No. 1) 300 tons of blooms and 200 tons of bars.

142. Soundwell Forge, situated sixteen miles north of Chambersburg, on Conedogwinit creek, and eleven miles west of Shippensburg station on the Cumberland Valley railroad, owned by Sheffler & Fleming, Roxbury P.O. Franklin county, built in 1790, has 3 forge fires, 1 run out fire, and 2 hammers worked by water, made in 1855 20 tons of blooms and 30 of bars and is probably the same as Roxbury Forge which is abandoned.

142.5. An Old Forge three miles south of Shippensburg, was torn down in 1849.

143. Northeast Forge, situated eleven miles west of Chambersburg on Broad Run, owned by John Beaver and P. Stenger, Loudon P.O. Franklin county, built in

1834, has 1 forge fire and 1 hammer worked by water, and in 1854 made 25 tons of bars. It is probably abandoned.

144. Valley Forge, situated fifteen miles west of Chambersburg on west Conecocheague creek two miles north of Loudon, owned by John Beaver, Loudon P.O. Franklin county, leased to John Polsgrove, built in 1804, has one forge fire and 1 hammer worked by water, and in 1856 made perhaps 40 tons of bars.

144.3. Loudon Forge and Furnace, in the edge of Loudon, were destroyed about 1840.

144.5. Mount Pleasant Forge and Furnace, four miles northwest of Loudon, were destroyed in 1843.

144.7. Hanover Forge and Furnace, in the Cove nine miles below McConnelsburg, Fulton county, have not been used for some years and are in ruins.

145. Carrick Forge (Iron Works), situated nineteen miles northwest of Chambersburg, viâ Loudon and four miles south-southwest of Fannetsburg, owned by James R. Brewster Fannetsburg P.O. Franklin county, leased to Samuel Walker, built in 1846, has 3 forge fires and 1 hammer worked by water and made in 1856 about 40 tons of blooms and 30 tons of bars.

146. Warren Forge (and Furnace), situated seven miles northeast of Hancock Maryland, in the redshale cove of Licking creek, owned by William Bowers' heirs Sylvan P.O. Franklin county, leased to Reuben Lewis & Co. built in 1832, has 1 forge fire and 1 hammer, driven by water, and in 1856 made 45 tons of blooms.

147. Ashland Bloomery, situated on Aquanchicola creek, seven miles east of Lehigh Gap station, owned by Eugene A. Trueauff Lehigh Gap P.O. Carbon county, built in 1820, has 3 forge fires, 2 hammers driven by water, and made in 1856 130 tons of bars.

148. Maria Forge, situated on Poco creek, three miles east of Weissport, owned by Samuel Balliet & Co. Weissport P.O. Carbon county, built in 1753, rebuilt in 1846, has 2 forge fires, 2 puddling furnaces and 1 hammer, driven by water, and made in 1856 perhaps 78 tons of bar.

149. Weissport Forge, situated in Weissport, on the Lehigh Valley Railroad, owned by Mr. Weiss, Weissport P.O.

Carbon county, built in 1853, has 2 forge fires, 1 hammer driven by steam, was built to manufacture railroad axles.

150. Pennsville Forge, situated on Lizard creek four miles southwest of Lehighton station, owned by Charles H. Nimson, East Penn P.O. Carbon county, built in 1829, rebuilt in 1856, uses one of its 4 forge fires, has 2 hammers driven by water, and made in 1855 18 tons of blooms and 27 of bars.

151. Tamaqua Iron Works, situated at Tamaqua, on the Little Schuylkill railroad, owned by Carters & Allen, Tamaqua P.O. Schuylkill county, built in 1846, has been in operation 11 years, and consists of foundry, machinery, car, boiler and smith shops, covers an area of 500 × 250 feet, has 1 heating furnace, 11 forge fires, and one 3 to 4 ton Nasmyth steam hammer, driven by two engines, and two large cupolas, makes at present 200 car-wheels per month, and can build fifteen four-wheel cars a month.

152. Hecla Forge, situated near the Little Schuylkill Railroad, thirty-one miles above Reading, owned by Matthew V. Richards, Reading and Ringold P.O. Schuylkill county and managed by Jacob G. Coleman, built in 1828, has 3 forge fires and 2 hammers driven by water, and made in 1854 350 tons of blooms. It was abandoned when the drift coal dust filled up its dam.

153. Schuylkill Forge, owned by John Schall, of the firm of Schall & Taylor Port Clinton, Schuylkill county, built in 1801, has 5 forge fires, 2 hammers driven by water, made in 1849 283 tons of blooms and bars and is now abandoned.

153.5. Susanna Forge is abandoned.

153.6. Mount Vernon Forge is abandoned.

154. Brunswick Forge, owned by Koch, Hammer & Huntzinger, Port Clinton, Schuylkill county, built in 1816, has 2 forge fires and 1 hammer, driven by water, and is now abandoned.

155. Mt. Hebron Forge, situated on the Mohontongo creek in the red shale valley, between the Broad and Locust mountains, three miles southwest of Ashland, owned by Dr. Otto, Easton and managed by J. B. Otto, Barry P.O. Schuylkill county, built in 1826, has 3 forge fires and 2 hammers, driven by water, and made in 1855, perhaps 200 tons of bars chiefly.

156. Oakdale Forge, situated on Wiconisco creek, thirty miles north of Harrisburg, owned by David K. McClure, Oakdale P.O. Dauphin county, built in 1830, has 5 forge fires, 2 hammers driven by water and made in 1856 237 tons of blooms and bars.

157. Stonydale Forge, situated on Stony Brook, on the south side of the Third or Coal Mountain, on the Dauphin and Susquehanna railroad, thirteen miles north of Harrisburg, owned by Snyder & Kinzer, Harrisburg P.O. managed by E. E. Kinzer, Dauphin county, built in 1850, has 3 forge fires, 1 hammer driven by water, and made in 1856 430 tons of blooms.

158. Nescopic Forge, situated on Nescopic creek two miles south of Berwick, owned by Headley A. Westler & Company, and managed by N. G. Westler, Berwick P.O. Luzerne county, built in 1824, has 4 forge fires and 2 hammers driven by water, and made in 1855 245 tons of blooms and bars.

159. Catawissa Forge, situated on Catawissa creek, six miles east of Catawissa, in front of the Gap in the Nescopic mountain, owned by G. & R. Shuman, leased by J. L. & W. T. Shuman, Maineville P.O. Columbia county, built in 1824, has 4 forge fires, 2 hammers driven by water, and made in 1855 60 tons of blooms and 87 of bars.

160. Paxinas Forge, situated on Shamoken river, three miles below Shamoken, owned by Jacob Leisenring, Bear Gap, and William Duard Sunbury, Northumberland county, Andrew Tar lessee, built in 1844, rebuilt in 1851, has 1 forge fire, 1 hammer driven by water and made in 1854 350 tons of blooms.

161. Berlin Forge, situated in Clinton, north of Jack's Mountain, 2 miles from Hartleton, owned by John Church & Co. Hartleton, Union county, built in 1827 has 4 forge fires and 1 hammer driven by water, and made in 1854 300 tons and nothing since.

161.5. Rebecca Forge and Furnace, on Standing Stone creek, 12 miles above Huntingdon, are in ruins.

162. Freedom Forge, situated west of the Juniata river, seven miles southwest of Lewistown, owned by John A. Wright & Co. Lewistown, Mifflin county, built in 1810, has 8 forge fires and 5 hammers driven by water, and made in 1856 930 tons of blooms and 380 of bars.

163. Brookland Forge, situated on the canal, at the edge of the village of Waynesburg, about 12 miles southwest of Lew-

istown, owned by the Brookland Iron Company managed by G. W. McBride Waynesburg, Mifflin county, built in 1839, has 3 forge fires, 3 puddling fires, and 1 hammer driven by water, and is said to have made in 1856 10 tons of wire billet per day for 7 months.

163.5. **Orbisonia Forge,** Huntingdon county, is in ruins.

164. Malinda Forge, situated four miles south-southwest of Orbisonia, and one hundred yards above Malinda Furnace, owned by J. & L. Sheffer, and managed by T. E. Orbison, Orbisonia, Huntingdon county Pennsylvania, built in 1842, had 3 forge fires, but now has one refinery and one bloomery fire and 2 hammers driven by water, and made in 1856 about 450 tons of blooms.

165. Lemnos Forge and Furnace, situated on Yellow creek, five miles west of Hopewell, owned by Madara & King and managed by William Madara, Allequippa P.O. Bedford county Pennsylvania, built in 1807, has 3 forge fires and 1 hammer driven by water, and made in 1855 450 tons of blooms.

166. Bedford Forge, situated on Yellow creek five miles west of Hopewell, owned by John King & Company, managed by Thomas King, Allequippa P.O. Bedford county, built in 1813, has 3 forge fires and 2 hammers driven by water, and makes about 150 tons of bars annually.

167. Hepburn Forge, situated on Lycoming creek just inside the mouth of the gorge of the Alleghany Mountain, twelve miles north of Williamsport, owned by J. W. Heilman, Crescent P.O. Lycoming county, built in 1830, has 2 forge fires and 2 hammers driven by water, and made in 1855 40 tons of blooms and 30 tons of bars.

168. Heshbon Forge (Furnace and Rolling Mill), situated on Lycoming creek, opposite McKinney's bridge station, on the Williamsport and Elmira railroad, five miles north of Williamsport, owned by William McKinney Williamsport, built in 1828, has 2 forge fires, 2 run-out fires and 1 hammer driven water, and made in 1855 perhaps 300 tons of rolling mill bars.

169. Washington Forge, situated 13 miles northeast of Bellefonte, owned by James Irwin of Bellefonte, Nittany P.O.

Clinton county, built in 1837, has 4 forge fires, 1 run-out fire, and 3 hammers driven by water, and has made annually perhaps 350 tons of blooms.

170. Howard Forge (and Rolling Mill), situated on Lick Run, twelve miles northeast of Bellefonte, owned by Irvin, Thomas & Company, managed by John Irvin Jr. Howard P.O. Centre county, built in 1840, has 4 forge fires, and 1 hammer driven by water, and made in 1856 291 tons of blooms.

171. Eagle Forge, situated on Bald Eagle creek, and Bald Eagle and Spring creek canal, five miles northeast of Bellefonte, owned by C. & J. Curtin, Eagle Furnace P.O. Centre county, built in 1811, has 7 forge fires, 1 run-out fire, and 2 hammers driven by water, and made in 1856 660 tons of blooms.

172. Milesburg Forge, situated on Spring creek, Bellefonte; Phillipsburg Turnpike, two miles north of Bellefonte, owned by Irvin, McCoy & Co. managed by James H. Linn, Milesburg, Centre county, built in 1800, has 4 forge fires, 2 puddling fires, and 2 hammers driven by water, and made in 1856 615 tons of blooms.

173. Bellefonte Forge, situated on the Logan branch of Spring creek, thirty miles from Lockhaven via canal owned by Valentines, Thomas & Co. managed by R. B. Valentines Jr. Bellefonte Centre county, built in 1795, has 6 forge fires, and 1 hammer driven by water, and made in 1856 710 tons of blooms.

174. Rock Forge, close by Rock Furnace, six miles southeast of Bellefonte, owned by William F. Reynolds, Bellefonte, Centre county, built in 1832, has 1 bloomary fire, 3 forge fires and 2 hammers driven by water, and made in 1855, about 250 tons of blooms and bars and nothing since.

175. Coleraine Forges, Nos. 1, 2, 3, situated three miles northeast of Spruce creek, owned by Lyon, Shorb & Co. managed by S. C. Stewart, Spruce creek Huntingdon county, built in 1805, have 7 forge fires and 3 hammers driven by water, and made in 1856 784 tons of blooms.

176. Elizabeth Forge, situated on Spruce creek, one mile below Coleraine Forges, Huntingdon county, owned by J. & G. H. Shönberger, Pittsburg (Alleghany county), built in 1826,

has 3 forge fires, 1 run-out fire and 1 hammer, driven by water, and made in 1849 490 tons of blooms, and nothing since 1853.

177. Barre Forges, Nos. 1 and 2, situated on the Little Juniata three miles above Petersburg, and opposite Barre Station, Pennsylvania railroad, owned by Joseph Green & Co. managed by Col. G. Dorsey Green, Barre P.O. Huntingdon county, built in 1800, has 5 forge fires, 2 run-out fires and 1 hammer driven by water, and made in 1855 677 tons of blooms.

178. Juniata Forge, No. 1, situated near Petersburg on the Pennsylvania railroad and Little Juniata river, owned by A. P. Wilson, leased by B. Lorenz and S. F. Cooper, Petersburg P.O. Huntingdon county, built in 1837, has 5 forge fires, 1 run-out fire and 1 hammer, driven by water, and made in 1855 675 tons of blooms.

179. Juniata "Iron Works" Forge, No. 2, situated on the Juniata river, four miles above Petersburg and one mile east of Alexandria, owned by S. Hatfield, Jun., Alexandria, Huntingdon county, built in 1837, has 6 forge fires, 1 run-out fire and 1 hammer driven by water, and made in 1856 428 tons of blooms.

180. Stockdale Forge, situated on Spruce creek and Little Juniata river, near Spruce creek station Pennsylvania railroad, owned by John S. Isett, leased and managed by James Garden, Spruce creek P.O. Huntingdon county, built in 1836, has 2 forge fires, 1 run-out fire, and 1 hammer driven by water, and made in 1856 258 tons of blooms.

181. Cold Spring Forge, situated on the Little Juniata river, a half mile west of Tyrone, Pennsylvania railroad, owned by Edward B. Isett, Tyrone P.O. Blair county, built in 1833, has 2 forge fires, 1 run-out fire, and 1 hammer driven by water, and made in 1856 285 tons of blooms.

182. Tyrone Forges, situated on the Pennsylvania railroad, two miles east of Cold Spring station, Blair county, owned by Lyon, Shorb & Company of Pittsburg, Alleghany county, built in 1804, has 11 forge fires and 3 hammers driven by water, and made in 1856 1,254 tons of blooms.

183. Antes Forge, situated a third of a mile south of Tipton, Pennsylvania railroad, owned by Graham McCamant's heirs, leased by Martin Bell, Elizabeth Fur-

nace P.O. Blair county, built in 1813, has 4 forge fires, 1 run-out fire and 1 hammer driven by water, and made about 400 tons a year of blooms and slabs, but has been abandoned since 1853.

184. Mary Ann Forges, Nos. 1 and 2, situated a mile south-southeast of Bell's Mills, owned by John Bell, Antestown P.O. Blair county, built in 1829, have five forge fires, 1 run-out fire, and 2 hammers driven by water, and made in 1856 about 400 tons of blooms and 12 of bars.

185. Etna Forge, situated on the Pennsylvania canal five miles southwest of Alexandria, owned by Isett, Keller & Co., Etna Furnace P.O. Blair county, has 4 forge fires, 2 run-out fires and 1 hammer, driven by water, and made in 1856 perhaps 450 tons of blooms.

186. Cove Forge, situated on the Juniata river, seventeen miles east of Holidaysburg via Pennsylvania canal, and eight miles southwest of Alexandria, owned by John Royer & Co. managed by A. Rutledge, Williamsburg P.O. Blair county, has 2 forge fires, 1 run-out fire, and 1 hammer driven by water, and made in 1856 339 tons of blooms.

187. Franklin Forge, situated on the canal and Juniata river, two miles west of Williamsburg, owned by Daniel H. Royer, leased by Sewell, Stewart & Co., Williamsburg P.O. Blair county, built in 1829, rebuilt about 1851, has 4 forge fires, 1 run-out fire, 1 hammer, driven by water, and made in 1854 600 tons of blooms, and nothing since.

188. Maria (Lower) Forge, situated just above McKee's Gap in Bald Eagle Mountain, seven miles south-southwest of Holidaysburg, owned by Shönberger's heirs, leased by D. C. McCormick and managed by William Forbes, Holidaysburg, Blair county, built about 1829, has 5 forge fires, 1 run-out fire and 2 hammers driven by water, and made in 1856 494 tons of blooms.

189. Maria, Middle Forge, a quarter of a mile above the last, and three or four hundred yards below the next, owned by J. H. Duncan, Spang's Mills P.O. managed by John King, Blair county, built about 1826, has 6 forge fires, 1 run-out fire and 1 hammer, driven by water, and made in 1856 838 tons of blooms.

190. Maria, Upper Forge, nearly eight miles south-southwest of Holidaysburg, owned by J. H. Duncan, Spang Mills P.O. Blair county, and managed by John King, built about 1820, has 3 forge fires and 1 hammer driven by water, and made in 1855 254 tons of blooms.

191. Martha Forge, situated nearly seven miles south-southwest of Holidaysburg, three hundred yards above Martha (Gap) Furnace, on Cove creek, has 5 forge fires, 1 run-out fire, 1 hammer driven by water, and made in 1856 perhaps 700 tons of blooms.

192. Alleghany Forge, situated on the Juniata river, nearly six miles northwest of Holidaysburg, owned by Mrs. E. Lytle, and managed by James Hemphill, Holidaysburg Blair county, built about 1831, has 5 forge fires, 1 run-out fire and 1 hammer driven by water and made in 1855 901 tons of blooms.

193. Portage Forge and Rolling Mill, situated two miles west of Holidaysburg, owned by Burroughs, Higgins, Royer & Schmucker, managed by Joseph Higgins, Duncanville Blair county, has 3 forge fires and 1 hammer driven by water, but has been disused for several years.

194. Navy Yard Forge, situated one mile southeast of the capitol, on the east bank of the Potomac, in the District of Columbia, owned by the United States Government, James Tucker superintendent of the Blacksmith's Department, built about the year 1812 and rebuilt about 1832, has 10 heating fires and 4 hammers worked by steam, and in 1857 made 483½ tons of anchors, shafts, chains, etc.

195. Armory Forge, situated at the forks of the Potomac and Shenandoah rivers, owned by the United States Government, superintended by Henry W. Clowe, Harper's Ferry, Jefferson county Virginia, built in 1854, has 4 fires in all and 1 hammer worked by water, and in 1856 made 50 tons of arms.

196. South Bend Forge, situated ten miles east of Charlestown on the Shenandoah river Virginia, owned by Charles Brooke, Wagentown, Chester county Pennsylvania, built in 1835, rebuilt in 1838, has 4 fires in all, and 1 hammer worked by water, and made blooms. Not in operation since 1856.

197. Bloomary Forge, situated twenty-five miles northwest

of Winchester, on Cacapon river, two miles below Bloomary Furnace, owned by C. W. Pancoast & James Magee, 403 Walnut street Philadelphia, and Paw-paw tunnel P.O. Hampshire county Virginia, built in 1852, rebuilt in 1855, has 5 fires in all and 2 hammers worked by water and in 1856 made perhaps 200 tons of bars.

198. **Rock Forge,** situated on Decker's Creek three miles east of Morgantown, owned and managed by Edgar C. Wilson, Morgantown P.O. Monongalia county, has 3 fires in all and 1 hammer worked by water, and made bars, but has been out of blast for about 4 years.

199. **Capon Forge,** situated twenty-five miles southwest of Winchester on the Cacapon river, owned and managed by J. J. Kelly, wardensville P.O. Hardy county, has 4 fires in all and 2 hammers driven by water and in 1855 made perhaps 220 tons of blooms and bars.

200. **Harmony Forge,** situated on Passage creek, eight miles southwest of Front Royal and six miles southeast of Strasburg, owned and managed by Peter R. Bell, Water Lick P.O. Warren county, built in 1855, has 2 fires in all and 1 hammer worked by water and in 1855 made 12 tons of blooms.

201. **Union Forge, A,** situated on Stony Creek, six miles southwest of Woodstock, owned by Lantz & Rinker, managed by Samuel B. Lantz, Lantz's Mills P.O. Shenandoah county, built in 1850, has 5 fires in all, and 2 hammers worked by water, and in 1857 made about 234 tons of blooms and bars.

202. **Valley Forge, A,** situated eight miles southwest of Woodstock on Stony creek, one mile below Columbia Furnace, owned by Wissler & Myers, Columbia Furnace P.O. Shenandoah county, built in 1832, has five fires in all and 2 hammers worked by water and in 1856 made about 225 tons of blooms and bars.

203. **Liberty Forge,** situated twelve miles southwest of Woodstock, on Stony creek, owned by Walter Newman and managed by Benjamin P. Newman, Liberty Furnace Shenandoah county, built in 1828, has 4 fires in all and 2 hammers worked by water and makes annually about 20 tons of bars.

204. **Pine Forge,** situated three and a half miles north of Newmarket and sixteen miles southwest of Woodstock, owned and managed by Philip E. Frederick, Newmarket P.O. Shenan-

doah county, built in 1725 and rebuilt in 1835, has 3 fires in all and 2 hammers worked by water, and makes annually perhaps 50 tons of bars.

205. Speedwell Forge, No. 1, situated on Hawksbill creek one and a half miles north of Luray, owned by Henry Forrer Shenandoah P.O. Page county, and managed by J. Geary, built in 1815, has 3 refining and 1 run-out fires and 1 hammer worked by water and in 1856 made 119 tons of anconies.

206. Speedwell Forge, No. 2, situated two miles north of Luray, half a mile below No. 1, owned by Henry Forrer and managed by John Geary, Luray P.O. Page county, built about 1820, has 1 chafery fire and 1 hammer worked by water and in 1856 made 162 tons of bars.

207. Catharine Forge, No. 1, situated three miles west of Newport, fifty rods below Catharine Furnace, owned and managed by John McKiernan Alma P.O. Page county, has 1 refinery, 1 chafery and 1 run-out and 1 hammer worked by water and in 1856 made perhaps 76 tons of blooms and bars.

208. Catharine Forge, No. 2, situated three miles west of Newport, fifty rods west of Catharine Forge No. 1, owned and managed by John McKiernan, Alma P.O. Page county, built in 18—, has 1 refinery and 1 chafery fire and 1 hammer and its production is included in the last.

209. Shenandoah Forge, situated nine miles south of Newport, on main branch of Shenandoah, owned lately by D. & H. Forrer, who are at present its lessees, Shenandoah Iron Works P.O. Page county, has 5 refinery and 1 run-out fires and 2 hammers worked by water and in 1856 made about 300 tons of blooms.

210. Mount Vernon Forge, situated on the Shenandoah three miles south of Port Republic and one mile north of Weir's cave, John Miller owner, Wm. G. Miller Port Republic P.O. Rockingham, built in 1810 and rebuilt in 1855, has 4 refinery, 1 chafery, 1 run-out fire and 2 hammers worked by water and makes annually perhaps 150 tons of bars and slabs.

211. Mossy Creek Forge, situated on Mossy creek and on Warm Springs and Harrison turnpike, fifteen miles north of

Staunton, owned and managed by Daniel Forrer, Mossy Creek P.O. Augusta county, built in 1757, rebuilt in 1767 and in 1836, has a refinery and a chafery fire and 2 hammers worked by water, and in 1856 made perhaps 75 tons of bars.

212. Union Forge, B, situated on South river, thirteen miles southeast of Staunton, and one and a half miles south of Waynesborough, owned and managed by James E. Irvine, Waynesborough P.O. Augusta county, built about 1800 and rebuilt in 1850, has 2 refinery, a chafery and a run-out fire and 2 hammers worked by water, and has made annually perhaps 110 tons of bars.

213. Gibraltar Forge, situated on the North river, nine miles north of Lexington, owned by W. W. Davis, managed by J. Cole Davis, Rockbridge Baths P.O. Rockbridge county, built about 1800, rebuilt about 1845, has 3 refinery and a chafery fire, 1 hammer driven by water, and in 1856 made 154 tons of blooms.

214. Lebanon Valley Forge, situated ten miles north of Lexington, on North river, one and a half miles northwest of Cedar Grove, owned by M. Bryan, leased to W. W. Davis, Rockbridge county, built about 1825, has 4 fires in all and 2 hammers worked by water, and in 1856 made perhaps 200 tons of bars.

215. Buffalo Forge, situated on Buffalo creek, half a mile northwest of North River canal, and nine miles south-southeast of Lexington, owned and managed by William Weaver, Saunder's Store P.O. Rockbridge county, built about 1800 and rebuilt about 1840, has 4 fires in all and 2 hammers worked by water, and has annually made about 100 tons of bars.

216. James River Forge, situated eleven miles west of Buchanan in Botetourt county, built by William Ross about 1825 and rebuilt about 1845, was abandoned twelve or fifteen years ago and no trace of it is left.

217. Brunswick Forge, situated four and a half miles above Fincastle on Catawba creek, in Botetourt county, was abandoned about eight years ago, and is all in ruins.

218. Globe Forge, situated on Simpson's creek, seventeen and a half miles east of Covington, owned and managed by Edwin & Ira F. Jordan, Cow Pasture P.O. Alleghany county, built about 1832, has 3 fires in all and 1 hammer worked by water, and has annually made about 45 tons of bars.

219. Clifton Forge, situated thirteen miles east of Covington on Jackson's river and four miles east of Jackson's River station, owned and managed by W. L. Alexander, Clifton Forge P.O Alleghany county, built in 1824 and rebuilt in 1827, has 3 refinery, a chafery and a run-out fire and 2 hammers worked by water, and has made about 130 tons of bars annually.

220. Exchange Forge, situated on Dunlap's creek two miles west of Covington, and five and a half miles west of Dolly Ann Furnace, owned by W. T. Jordan & Co. of Covington, and leased to B. J. Jordan & Co. Alleghany county, built in 1848, has 5 fires in all and 1 hammer worked by water, and in 1856 has made annually about 50 tons of bars.

221. **An old Forge,** situated one mile above Newcastle on Craig's creek, Craig county built about 1830, and managed by Jordan, was abandoned ten or fifteen years ago.

222. **An old Forge** on Walker's creek, in Giles county, owned by Anslem Brawley, was abandoned before April 1854.

223. Bill's Bloomary or (Snowhill) Forge, situated twelve miles southwest of Christiansburg, on west bank of Little river, ten miles east of Newbern, owned and managed by David B. Bill, Snowville P.O. Pulaski county, built about 1845, has 3 bloomary fires and 1 hammer worked by water and has made about 62 tons of bars per annum from brown hematite ore.

224. Valley Forge, B, situated on Big river five and a half miles west of Franklin C.H. and twenty-five miles east of Floyd C.H. owned and managed by Peter Saunders, Franklin Court House Franklin county, built about 1850, has 2 refinery fires, 1 run-out and 1 hammer worked by water, and has annually made perhaps 150 tons of bars.

225. Blue Falls Forge, situated on Smith's river twenty miles south of Franklin C. H. and five miles north of Union Furnace, owned by Samuel W. Hairston managed by Allen Farner Union Furnace P.O. Franklin county, built about 1852, has 2 refinery fires and 1 chafery, with 2 hammers worked by water and in 1855 made perhaps 100 tons of bars.

226. **Union Forge C,** situated five miles south of Blue Falls Forge, near Union Furnace, in Patrick county, was washed away in 1850 and never rebuilt.

227. Mayo Forge, situated on Mayo river thirty-five miles

southwest of Franklin Court House, and eleven miles south of Union Furnace, and fourteen miles east of Patrick Court House, owned by George W. and J. G. Penn, Penn's Store P.O. Patrick county, built in 1856, has 2 refinery fires and 1 chafery with 2 hammers worked by water and in 1856 made perhaps 25 tons of bars.

228. **Wilkinson Forge**, No. 2, situated three miles below Grayson's Springs, Carroll county, built by William Wilkinson about 1840, was abandoned more than six years ago.

229. **Wilkinson's Bloomary Forge**, No. 1, situated on Crooked creek four miles south of its junction with New river, and ten miles west of Hillsville, owned by Elisha Burnett & Sons, Hillsville P.O. Carroll county, built about 1832, has 1 bloomary fire and 1 hammer, worked by water, and makes annually perhaps 8 tons of bars from limestone ore.

230. **Old Pierce Forge**, situated fifteen miles north of Hillsville, on Little Reed Island creek, owned by David Pierce, Carroll county, was abandoned forty-five years ago and is now gone.

231. **Chestnut Forge**, situated on Chestnut creek, twelve miles west of Hillsville, Carroll county, owned by the heirs of John Blair, was abandoned five years ago and is in ruins.

232. **An old Forge**, situated two miles below Chestnut Forge in Carroll county, built about 1790, was abandoned fifty years ago and is now gone.

233. **Graham's Forge**, situated twelve miles east of Wytheville on Reed creek, under same roof with Graham's Rolling Mill, six miles southeast of Mack's Meadows, owned by David Graham and managed by Mitchell B. Tate, Graham's Forge P.O. Wythe county, built in 1800 and rebuilt in 1856, has 4 refinery fires and 1 hammer worked by water, and in 1856 made 161 tons of blooms and 23 tons of bars.

234. **Pierce's Bloomary Forge**, situated on Cripple creek thirteen miles southeast of Wytheville, and eleven miles west of Graham's Forge, owned by Alexander Pierce, leased to Robert Williams and H. E. Catron, Brownhill Wythe county, built in 1822 probably and rebuilt in 1853, has 2 fires and 1 hammer worked by water, and in 1856 made about 40 tons of bars out of Graham's ore.

235. **Chatwell Bloomary Forge**, situated on Cripple creek twelve miles about south of Wytheville, one mile above Pierce's Forge, owned by J. P. M. Zimmerman, leased to Robert San-

dus, Brownhill P.O. Wythe county, built about 1843, has 2 fires and 1 hammer worked by water and in 1856 made about 10 tons of bars out of Graham's ore.

236. Wilkinson's Bloomary Forge, No. 3, situated twelve miles south-southwest of Wytheville, owned by James Wilkinson, leased to Robert Sandus, Brownhill P.O. Wythe county, built about 1800, and rebuilt in 1846 and in 1850, has 2 fires and 1 hammer worked by water and makes annually about 9 tons of bars out of Graham's ore.

237. High Rock Forge, situated on Little Reed Island creek about twenty miles east of Wytheville, Wythe county, was abandoned six or seven years ago.

238. Davis' Forge, situated fifteen miles north of Marion, and seven or eight miles northeast of Chatham Hill Forge, one of the oldest in the region, was abandoned about ten years ago.

239. A Forge, fifteen miles north of Marion, near Davis' Forge, in Wythe county, begun in 1852, was never finished.

240. Barton's Bloomary Forge, situated on south fork of Holsten in Rye Valley, six miles south of Marion owned and managed by John H. Barton, Rye Valley P.O. Smyth county, built probably in 1807 and rebuilt in 1857, has 1 fire and 1 hammer worked by water and made in 1856 about $1\frac{1}{2}$ tons of bars.

241. Nicholses' Bloomary Forge, situated on the south fork of the Holsten, one mile southwest of Barton's Furnace and eight and a half miles northeast of Seven-mile Ford, owned by William K. and Franklin Nichols, Rye Valley P.O. Smyth county, built probably in 1807, has 2 fires and 1 hammer worked by water, and makes about 25 tons of bars annually.

242. Chatham Hill Forge, No. 1, situated nineteen miles northeast of Saltville, on the north fork of Holsten, Smyth county, was abandoned in 1837 or earlier.

243. Chatham Hill Bloomary Forge, No. 2, situated at Chatham Hill on the north fork of Holsten, eighteen miles northeast of Saltville and twelve miles north of Marion railroad station, owned and managed by Andrew Cox, Chatham Hill P.O. Smyth county, built in 1853, has 1 fire and 1 hammer worked by water and makes about 11 tons of bars annually.

244. Piney Cliff Bloomary Forge, situated on the north fork of the Holsten nine miles southwest of Salt Works Branch

Junction on Virginia and Tennessee railroad, and three mile, north-northeast of Saltville, owned by Thomas L. Preston, managed by Harry Powers Saltville P.O. Smyth county, built in 1847, has 1 fire and makes about 4 tons of bars annually.

245. **Fox Creek Forge,** situated on Fox creek ten miles south of Barton's Forge, and thirty-six miles west of Grayson Court House, owned and managed by James Nelson, Big Meadow P.O. Grayson county, built in 18—, has two fires and 1 hammer worked by water, made in 1854 about 4½ tons of bars and is now in ruins.

246. **Brown's Bloomary Forge,** situated on the south fork of the Holsten river seven miles south of Abingdon and thirty-five miles below Nicholses' Forge, owned and managed by James Brown, Abingdon P.O. Washington county, built about 1825 and rebuilt about 1841, has 2 fires and 1 hammer worked by water and makes about 2½ tons of bars annually.

247. **White's Forge,** No. 1, situated at White's Furnace on the north fork of Holsten, fifteen miles southwest of Saltville, Washington county, was abandoned twenty years ago and is now entirely gone.

248. **White's Forge,** No. 2, six miles west of White's Forge No. 1, on Brumley creek, Washington county, was abandoned twenty years ago and is now entirely gone.

249. **Howard's Bloomary Forge,** situated in New Garden on Lewis's creek, twelve miles north-northeast of Lebanon, and thirty miles northwest of Abingdon, owned by Johnson & John T. Howard, New Garden P.O. Russell county, built in 1853, has 1 fire and 1 hammer worked by water and makes 1 or 2 tons of bars per annum.

250. **Johnson's Forge,** situated on Copper creek, about fourteen miles west of Lebanon and two and a half miles southwest of Dickinsonville, Russell county, was abandoned from thirty to forty years ago.

251. **Moccasin Bloomary Forge,** situated on Moccasin creek five miles above Moccasin Gap in Clinch mountain, and five miles northeast of Estillville, owned and managed by William B. White Estillville P.O. Scott county, built in 1851, has 2 fires and 1 hammer worked by water and makes about 25 tons of bars annually.

252. **Milam Bloomary Forge,** situated on Martin's creek, sixteen miles west of Jonesville, owned by Bales, Edds & Co. and managed by Hunter Edds, Rose Hill P.O. Lee county, built in or about the year 1825 and rebuilt about 1847, has now

1 fire and 1 hammer worked by water and makes about 10 tons of bars annually.

253. Bowling Green Bloomary Forge, situated on Martin's creek fifteen miles west of Jonesville four miles southeast of Rose Hill P.O. owned by C. & R. M. Bales & Co. and managed by Robert M. Bales, Rose Hill P.O. Lee county Virginia, built in 1828 and rebuilt in 1857, has now 1 fire and 1 hammer worked by water and makes about 9 tons of bars annually.

254. Union Bloomary Forge, situated six miles northeast of Danbury on Snow creek, owned and managed by Alexander Martin, Martin's Lime Kilns P.O. Stokes county North Carolina, built in 1780 and rebuilt in 1854, has 1 fire and 1 hammer worked by water and annually makes about 7 tons of bars.

255. Tunnel Bloomary Forge, situated on Dan river twelve miles of Germantown, opposite Danbury, owned by the Stokes Iron Mining Company (R. D. Golding), managed by H. W. Adkins, Germantown P.O. Stokes county, built in 1843, has 2 fires and 1 hammer worked by water, and made annually about 40 tons of bars.

256. Frost's Bloomary Forge, situated one mile from Keyser's forge, owned by Dr. Pepper of Danbury, has been out of blast for six years.

257. Keyser's Bloomary Forge, situated on the Town Fork near its head six miles northwest of Germantown and ten miles southwest of Danbury, owned and managed by Philip Keyser, Germantown P.O. Stokes county, built in 1796, rebuilt in 1855, had 2 fires and 1 hammer worked by water and was abandoned several years ago.

258. Hill's Bloomary Forge, situated on Tom's creek, nine teen miles west of Danbury, owned and managed by William Hill, Tom's creek P.O. built in 1791 and rebuilt in 1853, has 1 fire and 1 hammer worked by water and annually makes about 20 tons of bars.

259. Fulk's Bloomary Forge, situated on Tom's creek two miles southwest of Tom's Creek P.O. owned by Pleasant Evans Surry county, has been out of use for three or four years and in disrepair.

260. Hiatt's Upper Bloomary Forge, situated on Ararat river thirteen miles north of Rockford, owned and managed by Gabriel Hiatt, Flat Shoal P.O. Surry county, built in 1851, has 2 fires and 1 hammer worked by water and in 1856 made about 47 tons of bars.

261. Hiatt's Lower Bloomary Forge, situated four miles below Hiatt's Upper Forge, owned and managed by Martin Hiatt Tom's Creek P.O. Surry county, built in 1845 and rebuilt in 1856, uses 1 of its 2 fires and 1 hammer worked by water and in 1856 made about 21 tons of bars.

262. Blackwood's Bloomary Forge, situated on Fisher's river five miles northwest of Rockford, owned and managed by N. H. Blackwood, Rockford P.O. Surry county, built in 1836, rebuilt in 1852, has 2 fires and 1 hammer worked by water, and in 1856 made about 15 tons of bars.

263. Cooper's Bloomary Forge (late Rutledge's), situated on Cody's creek near Fisher's river one mile above the Blackwood Forge, owned and managed by B. M. Cooper, Dobson P.O. Surry county, built in 1854, has 2 fires and 1 hammer worked by water and in 1856 made 27 tons of bars.

264. Hobson's Bloomary Forge, No. 1, situated on Forbush creek nine miles southeast of Rockford and five miles east of Yadkinville, owned and managed by Stephen Hobson, Republic P.O. Yadkin county, built in 1843, has 2 fires and 1 hammer worked by water, and in 1856 made about 16 tons of bars.

265. Hobson's Bloomary Forge, No. 2, situated on Deep creek two and one quarter miles north from Yadkinville, eight miles south of Rockford, owned and managed by Stephen Hobson, Republic P.O. Yadkin county, built in 1849, has two fires and 1 hammer worked by water and in 1854 made about 16 tons of bars.

266. Forbush Bloomary Forge, situated on Forbush creek, three miles east of Hobson's Forge No. 1, owned and managed by Jesse Outen, Forbush P.O, Yadkin county, built in 1837 and rebuilt probably in 1849, has 1 fire and 1 hammer worked by water and annually makes about 10 tons of bars.

267. Mount Carmel Bloomary Forge, situated on Mountain creek fourteen miles northeast of Lincolnton and twelve miles southeast of Newton, owned and managed by Isaac E. Plain, Mountain creek P.O. Catawba county, built in 1817 and rebuilt in 1853, has one fire and 1 hammer worked by water and in 1856 made about 16 tons of bars.

268. Rough-and-Ready Forge, situated on Mountain creek, twelve miles northeast of Lincolnton, owned and managed by J. M. Smith, Mountain creek P.O. Catawba county, has 2 fires and 1 hammer worked by water and in 1856 made about 44 tons of bars.

269. Jenny Lind Bloomary Forge on Maiden's creek, six miles south from Newton, and eleven miles north-northeast of Lincolnton, owned by A. F. & E. J. Brevard, Cottagehome P.O. Catawba county, has 1 fire and 1 hammer driven by water and made about 37 tons of bars in 1856.

270. Madison Bloomary Forge, on Leiper's creek, eight miles east-southeast of Lincolnton, owned by J. F. & R. D. Johnston, Springhill P.O. Lincoln county, built in 1827 and rebuilt 1852, has one fire and 1 hammer driven by water, and made in 1856 about 15 tons of bars.

271. Springhill Bloomary Forge, on Leiper's creek, half a mile southeast of the last, owned by C. W. & C. J. Hammerskold, Springhill P.O. Lincoln county, built about the beginning of the century and rebuilt in 1853, has 3 fires and 2 hammers, and makes about 100 tons a year of bars, out of iron-bank ore.

272. Mount Tirza Bloomary Forge on Leiper's creek four miles southeast of the last, owned and managed by R. A. Brevard, Cottagehome P.O. Lincoln county, has 2 fires and 2 hammers, and made in 1856 about 60 tons of bars.

273. Mount Welcome Bloomary Forge, on Leiper's creek two miles southeast of the last, owned by Joseph & Wm. Johnston, Lincolnton P.O. Lincoln county, has 2 fires and 2 hammers driven by water, and made in 1855 about 33 tons of bars.

274. High Shoals Forge, Puddling Furnace and Rolling Mill, six miles north of Gaston, Gaston county North Carolina, owned by the High Shoals Mining and Manufacturing Company, has been disused since 1854 and is in ruins.

275. Briggs' Iron Works, a bloomary, on Crowder's creek, six miles south from Dallas, owned and managed by Benjamin F. Briggs, Yorkville P.O. Gaston county, South Carolina, built in 1853, has 3 fires and 1 hammer driven by water and made in 1857 about 336 tons of blooms.

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276. Dixon's Bloomary Forge, on Knob creek, in Cleveland county, twelve miles northwest of Shelby and eighteen miles west from Lincolnton on the road to Rutherfordton, owned and managed by Gilbert Dixon, has hot-blast, and made in 1856 mould, bar, tyre and axle iron.

277. Buffalo Shoals Bloomary Forge, on Buffalo creek, two miles above Froneberger's Forge, nine miles east-northeast of Shelby, owned and managed by Joshua Beam, Shelby P.O. Cleveland county North Carolina, has 1 fire and 1 hammer driven by water and makes annually about 25 tons of wagon tyre, bar and plough moulds for home market, from Ormond's magnetic ore ; but the poverty and distance of the ore will cause the forge to be soon abandoned.

278. Froneberger's Bloomary Forge, on Buffalo creek, four miles northeast from Shelby and five miles north of Muddy creek junction, owned by D. Froneberger & Company, and managed by S. B. Oats, Shelby P.O. Cleveland county North Carolina, was built in 1855, has 3 fires and 2 hammers driven by water and made in 1857 120 tons of bars.

279. Buffalo Bloomary Forge, on Buffalo creek, eight miles east of Shelby, ten miles north-northeast of Buffalo Iron Works, and four miles south of Froneberger's Forge, owned and managed by William Roberts, Shelly P.O. Cleveland county North Carolina, built in 1815, rebuilt in 1856, has 2 fires and 1 hammer, and made in 1856 about 35 tons of bars and plough moulds for a South Carolina market, out of Brigg's Yellow Ridge Bank grey magnetic ore from under the west side of King's Mountain. There was a furnace and a forge in the immediate vicinity before the Revolution.

280. Buffalo Iron Works, a bloomary on Buffalo creek, one mile north of the State line, ten miles south-southeast of Shelby, owned and managed by Reuben Swan, New House P.O. Cleveland county North Carolina, built in 1850 and rebuilt in 1856, has 3 fires and 1 hammer, driven by water, and made in 1856 92 tons of bars.

281. Stices' Shoals Bloomary Forge, on First Broad river in Cleveland county, three miles north of the mouth and

six miles west of Swan's Forge, four miles south of Shelby, owned and managed by E. S. E. Chambers, Stices' Shoals P.O. Cleveland county North Carolina, built in 1848 and rebuilt in 1856, has 1 fire and 1 hammer driven by water, and made in 1857 about 24 tons of bars out of Ormand's bank magnetic ore.

282. Tumbling Shoals Bloomary Forge, on Second Broad river in Rutherford county thirteen miles southeast from Rutherford, fifteen miles west-southwest of Shelby, owned and managed by John W. Logan, Mooresborough, Cleveland county North Carolina, has 2 fires and 1 hammer, is driven by water, and made in 1856 perhaps 35 tons of bars out of magnetic ore.

283. Cherokee Ford Bloomary Forge, on Broad river, twenty-four miles north-northwest of Yorkville, twenty-six miles northeast of Spartanburg, owned by the Swedish Iron Manufacturing Company and managed by A. M. Latham, Cooperville P.O. Union District South Carolina, was built in 1840, has 4 fires, one puddling furnace and one hammer and made in 1856 about 240 tons of blooms for the rolling mill out of magnetic ore from the vicinity. It has 4 smith's shops attached.

284. Cherokee Iron Works Bloomary, situated on Broad river, owned by King's Mountain Iron Company, and managed by M. M. Montgomery, Cherokee Iron Works P.O. York District South Carolina, was built in 1836, has 3 bloomary and 2 refinery fires, and 2 hammers driven by water, and made in 1856 about 400 tons of blooms from magnetic ore.

285. Helton Bloomary Forge, situated on Helton creek, ten miles north-northwest of Jefferson, owned and managed by William Gowing, Helton P.O. Ashe county North Carolina, was built in 1829, completed about 1834, has 2 fires and 1 hammer driven by water, and made in 1856 perhaps 15 tons of bars, from fine hematite ore two miles distant.

286. Little Elk Creek Bloomary Forge, situated on Little Elk creek twenty-three miles northeast from Jefferson and seven miles southwest of Independence, owned and managed by John McMillan, Potato creek P.O. Ashe county North Carolina, was built about 1825 and rebuilt about 1840, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 perhaps 4½ tons of bars.

287. Little River Bloomary Forge, situated on Little river about ten miles above the mouth and about seven miles from the Virginia line, owned by S. H. Thompson and J. W. Alexander's heirs, J. H. Carson guardian, Glade Creek P.O. Ashe county North Carolina, was built about 1827, has 2 bloomary fires and 1 hammer driven by water and made in 1855 about 18 tons of bars.

288. Ballou's Bloomary Forge, situated twelve miles northeast of Jefferson, owned by Meredith Ballou, North Fork New river Ashe county North Carolina, was built about 1817 and washed away in 1832.

289. Old Bloomary Forge, situated on Little river was probably the first in the country before 1807, but was abandoned before 1817.

290. Harbard's Bloomary Forge, situated two miles below Helton's on Helton river Ashe county North Carolina, was built about 1807 and washed away about 1817.

291. North Fork Bloomary Forge, situated eight miles northwest of Jefferson, Ashe county North Carolina, was built by McNabb about 1825, abandoned in 1829 and swept off in 1840.

292. Laurel Bloomary Forge, situated fifteen miles west of Jefferson, Ashe county North Carolina, was built by Michaels, Daniels, Worth & Murchison about 1847 and abandoned in 1853.

293. Cranberry Bloomary Forge, No. 1, situated on Cranberry creek, twelve miles east of Jefferson, Ashe county North Carolina, was built about 1832 and washed away in 1845.

294. Cranberry Bloomary Forge, No. 2, situated fourteen miles south of Taylor's store, on Cranberry creek, owned by Twitty, Miller, Bymun and others, leased and managed by J. C. Harden, Watauga county, built in 1820, rebuilt in 1856, has 2 bloomary fires and 1 hammer driven by water, and made in 1857 about 17 tons of bars.

295. Toe River Bloomary Forge, situated five miles south of Cranberry No. 2, in Watauga county, owned and managed by William Buchanan, Yellow Mountain P.O. Yancey county, built about 1843, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 4 tons of bars from magnetic ore of superior quality.

296. Johnson's Bloomary Forge, situated six miles south of Cranberry No. 1, owned and managed by Abraham Johnson, Cranberry P.O. Watauga county North Carolina, built in 1841, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about $1\frac{1}{2}$ tons of bars.

297. Lovinggood Bloomary Forge, situated on Hanging Dog creek, two miles above Fain Forge, owned and managed by G. W. & H. Lovinggood, Murphey P.O. Cherokee county North Carolina, built from 1845 to 1853, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 13 tons of bars from lump ore.

298. Lower Hanging Dogs Bloomary Forge, situated on Hanging Dog's creek, five miles northwest of Murphey, owned by Joseph Hinson or others, Murphey P.O. Cherokee county, built in 1840, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 4 tons of bars from hematite ores 4 miles southeast.

299. Killian Bloomary Forge, situated a half mile below Hinson's Bloomary, and four miles northwest of Murphey Bloomary, Cherokee county North Carolina, was built about 1843, abandoned in 1849, and is now in ruins.

300. Fain Bloomary Forge, situated on Owl creek and two miles below Lovinggood Bloomary, owned by Mercer Fain, Murphey P.O. Cherokee county North Carolina, leased by James Dockry and others, built in 1854, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 24 tons of bars.

301. Persimmon Creek Bloomary Forge, situated on Persimmon creek, twelve miles southwest of Murphey, owned by Walker & Stiles Persimmon creek P.O. Cherokee county North Carolina, built in 1848, has 2 bloomary fires and 1 hammer driven by water, and made in 1855 about 45 tons of bars from red ore, obtained on Notley river, 7 miles east of Kilpatrick bank.

302. Shoal Creek Bloomary Forge, situated on Shoal creek five miles west of Persimmon creek Bloomary, owned by Spillman & Jones, Laurel Valley P.O. Cherokee county North Carolina, built about 1854, has 1 bloomary fire and 1 hammer driven by water and made in 1854 about ½ ton of bars.

303. Sequee (Stoup's) Bloomary Forge, at Sequee Furnace, three miles south of Clarksville, Habersham county Georgia, was built about 1830 and abandoned about 1835, and is in ruins.

304. Hodge's Bloomary Forge, in Habersham county Georgia, was abandoned very long ago.

305. Mossy Creek Bloomary Forge, situated on Mossy creek eighteen miles northeast of Gainesville, and fifteen miles

southwest of Clarksville, owned by Wilkinson Smallwood, Polkville, Hall county Georgia, and Horace Hinnon, Lee county, and leased by A. Cook, Habersham county, built about 1850, has 1 fire and 1 hammer driven by water, and made in 1855 perhaps 21 tons of bars.

306. Camp Creek Bloomary Forge, situated on Camp creek two miles south of Mossy creek Furnace, owned by Wilkinson Smallwood, Polkville P.O. Hall county Georgia, built in 1852, has 1 fire and 1 hammer driven by water, and made in 1855 about 12 tons of bars.

307. Poole Bloomary Forge, situated on Stamp creek close by Poole Furnace, and ten miles east of Cartersville, owned by B. G. Poole, Etowah P.O. Cass county Georgia, built in 1850, rebuilt in 1852, has 1 run-out fire, 1 heating fire, and 1 hammer driven by water, and made in 1855 perhaps 140 tons of blooms. It is now out of repair.

308. Etowah Bloomary Forge, No. 1, situated one hundred yards above Etowah Furnace, on Stamp creek Cass county Georgia, was built in 1838 and torn down in 1841.

309. Etowah Bloomary Forge, No. 2, situated at Etowah Furnace, on Stamp creek, Cass county Georgia, was built in 1841 and torn down about 1844.

310. Allatoona Bloomary Forge, situated three miles north of Allatoona, near Allatoona Furnace on Allatoona creek, Cass county Georgia, was built about 1846, and torn down 1852.

311. Ivy Log Bloomary Forge, situated on Ivy Log creek, has 2 fires and 1 hammer, but is now abandoned.

312. Hemptown Bloomary Forge, situated on Hemptown creek, fourteen miles southeast of Ducktown, and one mile and a quarter northwest of Morgantown, owned and managed by Heaton & Wilson, Morgantown P.O. Fannin county Georgia, built in 1852, has 1 fire and 1 hammer driven by water, and made in 1857 about 21 tons of bars.

313. Aliculsie Bloomary Forge, situated about three miles from Tennessee State line on Aliculsie creek, Murray county Georgia, was built about 1843 and abandoned about 1848.

314. Another bloomary forge, situated on Armuchy creek ten miles south of Lafayette on John McWilliams' land, Walker county Georgia, was built about 1848 and abandoned about 1850, has 2 fires and 1 hammer.

315. Lookout Bloomary Forge, situated on Lookout creek four miles south of Trenton, Dade county Georgia, formerly owned by Benjamin Hawkins, Trenton P.O. was abandoned in 1851 and is in ruins.

316. Polkville Bloomary Forge, No. 1, situated on Cane creek at Polkville Furnace, five miles east of Coosa river, opposite the Ten Islands, owned by Goode & Morris, Morrisville P.O. Benton county Alabama, built in 1843, rebuilt in 1857, has 1 puddling fire and 1 hammer driven by water, and made in 1856 perhaps 60 tons of blooms.

317. Polkville Forge, No. 2, situated alongside of No. 1, has 1 heating fire and 1 hammer driven by water, and made in 1856 perhaps 54 tons of bars out of pig iron.

318. Rob Roy Bloomary Forge, situated on Talladega creek one mile east of Eagle Bloomary and ten miles southeast of Talladega, owned by Wm. Curry & Co. Kelly's Springs P.O. Talladega county Alabama, built in 1853, has 2 fires and 1 hammer driven by water, and made in 1856 perhaps 20 tons of bars.

319. Eagle Bloomary Forge, situated three miles above Maria Bloomary, on Talladega creek, owned and managed by John J. Mitchell, Bowdon P.O. Talladega county Alabama, built about 1846, rebuilt about 1852, has 2 fires and 1 hammer driven by water, and made in 1855 perhaps 9 tons of bars.

320. Maria Bloomary Forge, situated on Talladega creek, five miles southeast of Talladega, owned by Riddle & Ragan, Talladega P.O. Talladega county Alabama, built in 1842, has 2 fires and 1 hammer driven by water, and made in 1855 35 tons of bars.

321. Amerine Bloomary Forge, situated sixteen miles southeast of Talladega, on the creek, and on the road between Wedowee and Talladega, owned by Richard and William Amerine Bowdon P.O. Talladega county Alabama, built in 1857, has 2 fires and 1 hammer driven by water, but is not yet in working order.

322. **Chinnibe Bloomary Forge,** situated seven miles east of Maria Bloomary, on Chinnibe creek, owned by Walker Reynolds, Mardisville, Talladega county Alabama, built in 1851, but is now abandoned and in ruins.

323. Camp Branch Bloomary Forge, situated eight miles southwest of Columbiana, owned and managed by Horace Ware, Columbiana P.O. Shelby county Alabama, built in 1851, com-

pleted in 1853, has 1 puddling fire and 1 hammer driven by water, and made in 1855 perhaps 40 tons of blooms.

324. Valley Bloomary Forge C, situated on Shoal creek, three hundred yards from Alabama Coal Company's railroad, and three miles southwest of Montevallo, owned by J. George & Co. Montevallo P.O. Shelby county Alabama, built in 1857, but not in working order.

325. Lower Yellow Leaf Bloomary Forge, twenty-five miles southeast of Montevallo, owned by J. George & Company, Montevallo P.O. Shelby county Alabama, was building in 1857.

326. Brantley's Bloomary Forge, situated seven miles west of Montevallo, on Little Cahawba river, owned by John Brantley Montevallo, Bibb county Alabama (in winter Burnsville Dallas county), built from 1840 to 1853, has 4 bloomary fires and 1 hammer driven by water, and made in 1856 perhaps 40 tons of bars.

327. Stroup's Bloomary Forge, situated in Township 20, Range V. east of Huntsville, and fifteen miles northwest of Montevallo, owned by Moses Stroup, McMath's P.O. Bibb county Alabama, built about 1837, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 15 tons of bars.

328. Camp's Bloomary Forge, situated on Shoult's creek nearly three miles east of Scottsville, owned by James Camp, Scottsville P.O. Bibb county Alabama, built in 1840, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 9 tons of bars.

329. Hill's (Lewis's) Bloomary Forge, situated two miles east (above) Brantley's Bloomary, on the Little Cahawba river, was abandoned in 1841, and nearly all gone.

330. Ware & Benson's Bloomary Forge, situated a quarter of a mile above Camp's Bloomary, on Shoult's creek Bibb county Alabama, was abandoned nearly twenty years ago and removed to Camp's Bloomary.

331. Hill's Bloomary Forge, No. 2, situated on Shoult's creek three miles above Scottsville, Bibb county Alabama, owned by James Hill, built in 1840, has 2 fires and 1 hammer driven by water, and made in 1856 about 3 tons of bars.

332. Fayette County Bloomary Forge, situated on Wilson's creek, twenty-five miles north-northeast of Columbus, and two miles northeast of Crossville, Fayette county Alabama, owned by Hale & Murdock, Columbus Lowndes county Missouri, and managed by William Lamb, Military Springs P.O. has 2 fires and 1 hammer driven by water, and made in 1856 about 15 tons of bars.

333. Ward Bloomary Forge, No. 1, situated seven miles north of Taylorsville, on the Laurel Fork of Holsten river, owned and managed by John Ward, Ward's Forge P.O. Johnson county East Tennessee, has 2 bloomary fires and 1 hammer driven by water, and made in 1855 50 tons of bars, but has been since torn down.

334. Ward Bloomary Forge, No. 2, situated three hundred yards below the Ward No. 1, owned and managed by John Ward, Ward's Forge P.O. Johnson county East Tennessee, built about 1849, has 2 bloomary fires and one hammer driven by water, and made in 1856 perhaps 50 tons of bars.

335. Warden's Bloomary Forge, situated on Laurel Fork of Holsten river, a half mile below the Ward Forge No. 2, owned by John J. Warden, Taylorsville P.O. Johnson county East Tennessee, was built in 1810, and wholly abandoned in 1850.

336. Wagner's Bloomary Forge, situated on Roan's creek, three miles above Ward's Forge, owned by Mrs. Margaret Wagner, leased by John M. Hockaday, Johnson county East Tennessee, built in 1795, (?) has 2 bloomary fires and 1 hammer driven by water, and made in 1855 perhaps 3½ tons of bars.

337. Ward's Bloomary Forge, situated on Roane's creek six miles south of Taylorsville, owned by T. Ward and J. Wagner Jr. Shown's Cross Roads, leased by Stout & Morely, Johnson county East Tennessee, built in 1851, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 perhaps 20 tons of bars.

338. Sandhill Bloomary Forge, situated on Roane's creek eight miles south of Taylorsville and two miles above Sand Spring Forge, owned and managed by A. B. Slimp, Baker's Gap P.O. Johnson county, built in 1851, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 35 tons of bars from hematite ore in the vicinity.

339. Sand Spring Bloomary Forge, situated on Roane's creek, nine miles south of Taylorsville, owned by C. K. Gillespie & wife, managed by J. J. Jones, Baker's Gap P.O. Johnson county, built in 1836, rebuilt in 1845, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 perhaps 25 tons of bars from hematite ore in the vicinity.

340. **Old Bloomary Forge,** a quarter of a mile above Sand Spring Bloomary, was built about 1817, and abandoned in 1835, and is now quite gone.

341. Dugger's Bloomary Forge, situated on Watauga river, sixteen miles south of Taylorsville, and four miles above the mouth of Roane's creek, owned by J. and W. Dugger, Cable's Valley P.O. Johnson county, built about 1807, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 2½ tons of bars.

342. Murphy's Upper Bloomary Forge, situated on Little Doe creek, twenty-five miles from and on the road to Elizabethton, and eight miles southwest of Taylorsville, owned by Abraham Murphy, Pandora P.O. Johnson county New Jersey, leased and managed by Charles Berry, built in 1852, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 40 tons of bars.

343. Murphy's Lower Bloomary Forge, situated nine miles southwest of Taylorsville, on Little Doe creek, and one mile southwest of Upper Bloomary, owned by Abraham Murphy, Pandora P.O. Johnson county East Tennessee, and leased by Benjamin Treadway, built in 1812, has 2 bloomary fires and 1 hammer driven by water, and made in 1855 about 50 tons of bars.

344. Howard's Upper Bloomary Forge, situated on the same stream and road as Murphy's Bloomaries, and twenty-two miles from Elizabethton, owned and managed by Howard & son, Pandora P.O. Johnson county, built about 1815, rebuilt in 1849, has 2 bloomary fires and 1 hammer driven by water, and made in 1855 about 20 tons of bars.

345. Howard's Lower Bloomary Forge, situated one mile above the Upper, owned by Samuel Howard, Pandora P.O. and leased by Godfrey D. Heaton, Johnson county East Tennessee, built about 1827, rebuilt in 1851, has 2 fires and 1

hammer driven by water, and made in 1856 perhaps 20 tons of bars from lump ore in the neighborhood.

346. Blevin's Bloomary Forge, situated on Beaver Dam creek one mile below King's Bloomary, and nine miles northwest of Taylorsville, owned by J. Thomas's heirs and Rutledge King, managed by Jesse Cole Jr. Shady P.O. Johnson county East Tennessee, built about 1817, rebuilt about 1837, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 7 tons of bars of hematite ore 3 miles distant.

347. King's Bloomary Forge, situated on Beaver Dam creek, twenty-five miles northwest of Elizabethton, owned by James King Sen. managed by Jesse Cole Jr. Shady P.O. Johnson county, built about 1821, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 15 tons of bars.

348. Stonedam Bloomary Forge, situated on Stony creek, one half mile above Speedwell Bloomary, owned and managed by John M. Smith, Elizabethton P.O. Carter county East Tennessee, built in 1851, has 2 fires and 1 hammer driven by water, and made in 1856 perhaps 55 tons of bars from hematite ore from Hodge bank.

349. Speedwell Bloomary Forge, situated on Stony creek, four miles above Union Furnace, owned by William Stover and Robert Cass, Elizabethton P.O. Carter county East Tennessee, built about 1806, has 2 fires and 1 hammer driven by water, and made in 1856 about 40 tons of bars from ore 2 miles distant.

350. Upper Carter Bloomary Forge, situated on Stony creek, at Union Furnace, owned by David W. Carter & Co. Elizabethton, was built in 1820 and rebuilt in 1841, and is now abandoned and in ruins.

351. Lower Carter Bloomary Forge, situated on Stony creek, below Union Furnace, owned by David W. Carter & Co. Elizabethton, Carter county East Tennessee, built about 1810, rebuilt in 1845, has 2 refinery fires and 1 hammer driven by water, and made in 1856 about 9 tons of bars.

352. Farm Hall Bloomary Forge, situated on Stony creek, four miles northeast of Elizabethton, owned and managed by John Nave Jr., Elizabethton P.O. Carter county East Tennessee, built in 1811, rebuilt in 1838, has 2 bloomary fires

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and 1 hammer driven by water, and made in 1856 about 40 tons of bars.

353. Purlieu Bloomary Forge, situated on Doe river, three miles east of Elizabethton, owned by J. K. Snapp's heirs and others, John Leslie agent, Elizabethton P.O. Carter county East Tennessee, built about 1830, has 2 fires and 1 hammer driven by water, and made in 1856 perhaps 12 tons of bars from brown hematite "cold short" and "red short" ores from openings south and east.

354. Elizabethton Bloomary Forge, situated on Doe river, at the east end of Elizabethton, owned by David W. Carter & Co. Elizabethton Carter county, built about 1797, rebuilt in 1830, has 2 refinery fires, 1 chafery fire, and 1 hammer driven by water, and made in 1856 about 100 tons of bars, from charcoal pig.

355. Reeves' Bloomary Forge, situated on Watauga river, one mile below Elizabethton, owned by James J. Tipton, Elizabethton, Carter county East Tennessee, built in 1839–40, and was abandoned in 1852.

356. Hampton's Bloomary Forge, situated nineteen miles east of Elizabethton on Doe river, leased and managed by Jenkins & Pierce, Doe river cove, Carter county East Tennessee, built in 1847, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 20 tons of bars from magnetic ore.

357. White's Bloomary Forge, situated in Greasy cove, at White's Furnace, was built thirty or forty years ago and abandoned in 1842.

358. River Bend Bloomary Forge, No. 1, situated fifteen miles northeast of Elizabethton, on the south fork of Holston river, owned by Joseph Meredith, River Bend, leased by O'Brien, Crumley & Godsey, Sullivan county East Tennessee, built in 1840, has 3 refinery fires and 1 hammer driven by water, and made with No. 2 in 1854 about 175 tons of bars.

359. River Bend Bloomary Forge, No. 2, adjoining No. 1, has the same owner, and the products of both forges are united in No. 1. It has 1 fire and 1 hammer.

360. Waterloo Bloomary Forge, situated on Beaver creek, three miles southwest of Paperville, and two miles southwest of Bristol, owned by Mrs. Cyrus King, Bristol P.O. Sulli-

van county East Tennessee, built about 1830, has 2 bloomary fires and 1 hammer driven by water, and made in 1855 about 18 tons of bars, since when it has done nothing.

361. Beaver Creek Upper Bloomary Forge, situated on Beaver creek, three miles below Waterloo Forge, leased by Adam & Benjamin Shipley, Bristol, Sullivan county, built about 1800, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 18 tons of bars from hematite ore from Sharp's bank, 10 miles east.

362. Beaver Creek Lower Bloomary Forge, one mile below the last, is in all respects like it and was abandoned in 1855.

363. Old Bloomary Forge, situated at the junction of Beaver creek and the south fork of Holston river, was abandoned in 1832, and is now all gone.

364. Cherokee Bloomary Forge, situated six miles south of Jonesborough, owned by Isaac Williams at Cox's store, leased by Orville Nelson, Washington county East Tennessee, built about 1845, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 6 tons of bars from Cherokee hematite ore.

365. Pine Grove Bloomary Forge, situated on Nolichucky river, eleven and a quarter miles below the Pleasant Valley Iron Works, owned and managed by James Mauk, Broylesville, Washington county East Tennessee, built about 1837, has 2 bloomary fires and 1 hammer driven by water, and made in 1855 2 tons of bars, but is now in ruins.

366. Aikens' Bloomary Forge, situated seven miles south of Jonesborough, on Limestone creek, has been abandoned for 20 years and is now all gone.

367. Click's Bloomary Forge, situated on Middle creek, eight miles east of Greenville, owned and managed by George Click, Camp creek P.O. Greene county East Tennessee, built in 1837, has 1 bloomary fire and 1 hammer driven by water and made in 1856 about 17 tons of bars.

368. Alexander's Bloomary Forge, situated a mile and a half below Click's, owned by G. Alexander's heirs, Stephen Jane administrator, leased by Wyatt & Jane, Camp creek, Greene county East Tennessee, built about 1835, has 1 bloomary fire and 1 hammer driven by water, and made in 1856 about 6 tons of bars.

369. Mountain Bloomary Forge, situated three miles south of Click's on Watery fork of Camp creek, owned and

managed by James Jennings, Camp creek P.O. Greene county East Tennessee, built in 1837, rebuilt in 1853, has 2 bloomary fires and 1 hammer driven by water, and made in 1855 perhaps 7 tons of bars.

370. Camp Creek Bloomary Forge, situated on Camp creek, seven miles southeast of Greenville, owned by Balis Jones, Fannin, J. & T. Kennedy, leased by Waddle and others, Camp creek P.O. Greene county East Tennessee, built about 1797, rebuilt in 1856, has 2 bloomary fires and 1 hammer driven by water and made in 1856 perhaps 17 tons from hematite ores.

371. Snapp's Bloomary Forge, situated on Camp creek, two miles below Camp Creek Forge, owned and managed by J. P. & A. E. Snapp, Camp creek P.O. Greene county East Tennessee, built about 1836, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 25 tons of bars.

372. Paint Creek Bloomary Forge, situated on Paint creek, three miles southeast from Jonesborough, to Warm Springs N. C. owned and managed by Montgomery Stuart, Limestone Springs P.O. Greene county East Tennessee, built about 1851, has 1 bloomary fire and 1 hammer driven by water, and made in 1856 about 7 tons of bars from hematite ore, from Cove creek bank.

373. Kelly's Bloomary Forge, situated sixteen miles south of Click's Forge, owned by Daniel H. Kelly, Limestone Springs, Greene county East Tennessee, was built in 1846, but abandoned about 1852 and is now in ruins.

374. Allen's Bloomary Forge, situated four miles above Kelly's Forge, Greene county East Tennessee, built about 1827, was abandoned about 1830, and is now quite gone.

375. Canada's Bloomary Forge, situated about thirteen miles west of Click's Forge, Greene county East Tennessee, was built in 1841 or '42, and washed away about 1847.

376. Brown's Bloomary Forge, situated twenty-one miles west of Click's Forge on Nolichucky river, Greene county East Tennessee, was built about 1827 and abandoned soon afterwards and is now in ruins.

377. Erpes' Bloomary Forge, situated on Causby creek, thirteen miles south of Newport, owned by Mr. Harper, Cocke county East Tennessee, was built between 1837 and '39, abandoned about 1847, and is now all gone.

378. Mossy Creek Bloomary Forge, situated ten miles north of Dandridge, Jefferson county East Tennessee, was built about 1795 and abandoned 45 years ago.

379. Dumpling Bloomary Forge, situated five miles west of Dandridge, Jefferson county East Tennessee, built about 1795, was abandoned 45 years ago.

380. Pigeon Bloomary Forge, situated on west fork of Little Pigeon river, seven miles south of Sevierville, Sevier county East Tennessee, owned and managed by John Trotter, Pigeon Forge P.O. built about 1820, has 1 bloomary fire and 1 hammer driven by water and made in 1856 perhaps 2 tons of bars.

381. Love's Bloomary Forge, situated on Little East Fork of Little Pigeon river, built by Wm. & James Love in 1837, Sevier county East Tennessee, was abandoned about six years ago.

382. Amerine Bloomary Forge, situated on Hess's creek, in Miller's cove, ten miles south-southeast of Marysville, owned and managed by George Amerine, Marysville or Tuckaleechee, Blount county East Tennessee, built about 1845, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 perhaps 15 tons of bars.

383. Shield's Bloomary Forge, situated on Little river, in Tuckaleechee cove, six miles east of Amerine Forge, Blount county East Tennessee, was built in 1843 and washed away, and but little of the ruins are remaining.

384. Abram's Creek Forge, situated on Abram's creek, six miles south of Amerine Forge, owned by Davis Fout, Blount county East Tennessee, built about 1627, was abandoned in 1853, and is now nearly gone.

385. Cade's Cove Bloomary Forge, situated ten miles south of Amerine Forge, owned by Davis Fout, Cade's cove, Blount county East Tennessee, built about 1827, was abandoned in 1847, and now nearly gone.

386. Tellico Bloomary Forge, situated on Tellico river at the upper end of Tellico Plains, owned by the Tellico manufacturing company, Elisha Johnson President and manager, Tellico Plains, Monroe county East Tennessee, built about 1825 and rebuilt 1837, has 3 refinery and one chafery fires, 2 hammers driven by water, and made in 1855 perhaps 225 tons of bars.

387. Cooke's Bloomary Forge, situated on Connesauga creek, three miles from Monroe county, and fourteen miles southeast of Athens, owned and managed by Daniel Thompson, Connesauga P.O. McMinn county East Tennessee, built in 1823, rebuilt in 1843, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 perhaps 10 tons of bars.

388. Overton's Bloomary Forge, situated on Mulberry creek, five miles from the Virginia line, and six miles south of Milam Forge, owned by Taylor Overton, Woodson's P.O. Han-

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cock county East Tennessee, was built about 1841, rebuilt in 1856, has 2 bloomary fires and 1 hammer driven by water, and makes bars.

389. Belleville Bloomary Forge, situated on Indian creek, at Belleville Furnace, five miles east of Cumberland Gap, owned by Reuben Rose, Tazewell, and George W. Rose, Cumberland Gap, Claiborne county East Tennessee, has one bloomary, 2 refinery fires, and one hammer driven by water, and made in 1856 about 30½ tons of bars.

390. Little Barren Bloomary Forge, situated eleven miles west of Tazewell, and twenty-two miles south of Cumberland Gap, owned hy William Kincade's heirs, I. Thomas, administrator, Old Town, Claiborne county East Tennessee, built about 1853, has 1 bloomary fire and 1 hammer driven by water.

391. Centreville Bloomary Forge, situated on Davis's creek, five miles east of Fincastle, owned by Elisha McNew, Well Spring P.O. Campbell county East Tennessee, built about 1827, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 6 tons of bars.

392. Speedwell Bloomary Forge, situated three miles west of Centreville Forge, eight miles southwest of Yocum's station, was built about 1815 and abandoned about 1830.

393. Baker Bloomary Forge, situated on Cedar creek, eleven miles east-northeast of Jacksborough, owned by John Comer and David Johnson, Fincastle P.O. Campbell county East Tennessee, built about 1817, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 8 tons of bars.

394. Richardson's Bloomary Forge, situated on Big creek, two miles south-southwest of Sharp's Forge, owned by William Richardson, Jacksborough P.O. Campbell county East Tennessee, built in 1827 or '28, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 20 tons of bars.

395. Sharp's Bloomary Forge, situated on Big creek, five miles northeast of Jacksborough, owned by Laban Sharp, Jacksborough P.O. Campbell county East Tennessee, built in 1857, has 2 bloomary fires and 1 hammer driven by water.

396. Queener Bloomary Forge, situated on Cove creek, two miles south of Jacksborough, owned by David Sharp, Jacksborough P.O. Campbell county East Tennessee, built about 1835, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 22 tons of bars from dyestone ore in the vicinity.

397. Lindsay Bloomary Forge, situated on Cove creek, about fourteen miles west of Miller's Furnace, and two miles east-southeast of Queener Furnace, owned by J. S. Lindsay and Squire Hunter, Jacksborough P.O. Campbell county East Tennessee, was built about 1833, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 perhaps 20 tons of bars.

398. England's Bloomary Forge, situated at the lower end of Anderson county in East Tennessee, on the Brushey Fork of Poplar creek, built about 1832 and abandoned 9 years ago.

399. Butler's Bloomary Forge, situated on Poplar creek, Anderson county East Tennessee, built about 1825 and abandoned twenty years ago.

400. Cobb's Bloomary Forge, situated six miles northwest of Campbell's Station, at the mouth of Beaver creek, owned by Archibald Cobb, Knox county East Tennessee, and abandoned in 1853.

401. Emory's Bloomary Forge, situated at the junction of Emory river and Poplar creek, Roane county East Tennessee, built between 1817 to 1827, and abandoned in 1846.

402. Eagle Bloomary Forge, No. 1, situated a quarter mile south of Eagle No. 2, Roane county East Tennessee, was built in 1848, abandoned in 1850, and replaced by a Grist and Saw Mill.

403. Gordon's Bloomary Forge, situated fifteen miles southwest of Kingston, Roane county East Tennessee, owned by George W. Short, Eagle Furnace, built in 1822, rebuilt about 1834, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 16½ tons of bars.

404. Eagle Bloomary Forge, No. 2, situated on White's creek, at Eagle Furnace, owned by East Tennessee Iron Manufacturing Company, R. Cravens, agent, Chattanooga, managed by S. Hardbarger, Eagle Furnace, Roane county East Tennessee, built in 1855, has 1 bloomary fire and 1 hammer driven by water, and made in 1856 about 7 tons of bars.

405. Turnpike Bloomary Forge, situated sixteen miles southwest of Kingston, owned by Alexander Robbs, Eagle Fur-

nace P.O. Roane county East Tennessee, built in 1847 or '48, has 1 bloomary fire and 1 hammer driven by water, and made in 1856 about 8 tons of bars.

406. **Montgomery's Bloomary Forge,** situated on White's creek, on Gordon's turnpike, eighteen miles southwest of Kingston, owned by Alexander Montgomery, Eagle Furnace, Roane county East Tennessee, managed by Robert Thompson, built about 1838, rebuilt in 1848, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 18 tons of bars.

407. **Kimbrough's Bloomary Forge,** situated on Turnpike creek, thirteen miles west of Kingston, owned by Joseph Kimbrough, Belleville P.O. Roane county East Tennessee, managed by Robert Kimbrough, built about 1832, rebuilt about 1845, has 2 bloomary fires and 1 hammer driven by water, and made in 1856 about 8½ tons of bars from dyestone ore in the vicinity.

408. **Upper Piney Bloomary Forge,** situated on Piney creek. ten miles southwest of Eagle Furnace, owned by H. P. Caldwell, Rhea Springs P.O. Rhea county East Tennessee, managed by William Fullington, built in 1848, has 1 bloomary fire and 1 hammer driven by water, and made in 1856 about 10 tons of bars.

409. **Lower Piney Bloomary Forge,** situated on Piney creek, a mile below Upper Piney Forge, owned by E. E. Waston, Rhea Springs, leased by William T. Lowry, Rhea county East Tennessee, built about 1849, uses 2 of its 3 bloomary fires, has 1 hammer driven by water, and made in 1856 6½ tons of bars.

410. **Richland Bloomary Forge,** situated on Piney creek, Rhea county East Tennessee, built about 1847, abandoned in 1852, and now in ruins.

411. **Farmer's Bloomary Forge,** situated on Fire creek three miles north of Decatur, claimed by Col. M. Johnson, Tellico Plains, and by others, Meigs county East Tennessee, built about 1843, abandoned in 1852 and '3, and now in ruins.

412. **West Fort Ann Bloomary and Forge,** No. 1, situated on a branch of Wood creek, five miles west of Fort Ann, Washington county New York, owned and managed by Caleb Kingsley, built in 1802, rebuilt about 1842, has 1 bloomary fire, 1 blacksmith fire, and 2 hammers driven by water, and made in 1854 about 25 tons of anchors and cranks.

413. West Fort Ann Bloomary and Forge, No. 2, a quarter of a mile above No. 1, on the same stream, leased by A. H. Wheeler, West Fort Ann, Washington county New York, built in 1828, has 1 bloomary fire and 2 blacksmith fires with 2 hammers driven by water, and made in 1856 about 40 tons of anchors and cranks.

414. Penfield's Bloomary, situated in Irondale on Putt's creek, six miles west of Crown Point, owned by Penfield, Harwood & Company, Crown Point P.O. Essex county New York, built in 1847, has 4 bloomary fires and 2 hammers driven by water, and made in 1856 about 500 tons of blooms.

415. Schroon River Bloomary, situated on the west branch of Schroon river, one mile south of Root's tavern, owned by E. B. Walker and county, managed by Jacob Parmerter, Essex county New York, built in 1857, has 2 bloomary fires, 1 blacksmith fire and 1 hammer driven by water, and makes blooms out of magnetic ore.

416. North Hudson Iron Works, on the west bank of Schroon river and the State road, eighteen miles south of Elizabethtown, owned by James S. Whallon, Whallonsburg P.O. Essex county New York, has 3 bloomary and 1 forge fire, with 1 hammer driven by water, and makes blooms out of magnetic ore.

417. Dead Water Bloomary, situated on the east bank of the stream, and 13 miles south of Elizabethtown, owned by James S. Whallon, Whallonsburg P.O. Essex county New York, has 4 bloomary fires, 1 blacksmith fire, 1 hammer driven by water, and makes blooms out of magnetic ore.

418. Noble's Bloomary, situated at the outlet of Black pond, six miles southeast of Elizabethtown, Essex county New York, owned and managed by Henry R. Noble, built about 1825 and rebuilt in 1845, has 2 fires and 1 hammer driven by water, and made in 1854 about 100 tons of blooms out of Sandford and Haasz magnetic ore.

419. New Russia Bloomary, situated on Bouquet river and the State road, twelve miles west of Westport and four miles south of Elizabethtown, owned and managed by Hiram Put-

nam, New Russia P.O. Essex county New York, was built about 1847 and rebuilt in 1856, has 3 bloomary and 1 forge fire with 1 hammer driven by water, and made in 1856 about 425 tons of blooms out of Barton magnetic ore.

420. Elizabethtown Ironworks, on Bouquet river at the north end of the village, owned by James S. Whallon, Whallonsburg P.O. Essex county New York, was repaired in 1856, has 5 bloomary and 1 forge fire with 1 hammer driven by water and steam, and made in 13 weeks 170 tons of blooms.

421. Westport Bloomary, on Bouquet river, four miles north of Westport, Essex county New York, owned and managed by William P. and P. D. Merriam, has 3 bloomary and 1 forge fire with 1 hammer driven by water, and has made about 600 tons of blooms per annum out of Moriah magnetic ore.

422. Whallonsburg Bloomary, on Bouquet river, in the village, four miles southwest of Essex, in Essex county New York, owned by James S. Whallon, has 4 fires with 2 hammers driven by water, and makes blooms out of magnetic ore.

423. Wilder's Bloomary, on the north branch of Bouquet river and the State road, four miles north of Elizabethtown, Essex county New York, owned and managed by A. H. Wilder, Lewis P.O. was built about 1844, has 2 bloomary and 1 forge fire with 1 hammer driven by water, and has made about 500 tons of blooms out of Moriah magnetic ore.

424. Merriam's Bloomary, on the north branch of Bouquet river, two miles east of the State road, six miles east of north of Elizabethtown, owned and managed by J. L. Merriam, Lewis P.O. Essex county New York, was built about 1837 and rebuilt 1853, has 3 bloomary and 1 forge fire with 1 hammer driven by water, and made in 1856 about 760 tons of blooms out of Moriah magnetic ore.

425. Willsborough Bloomary, in the village of Willsborough, Essex county New York, on Bouquet river, two miles west of Lake Champlain, owned by the heirs of William D. Ross and managed by H. H. Ross, was built about 1800, rebuilt 1850, has 5 bloomary and 1 forge fire with 2 hammers driven by water, and made in 1855 about 1,000 tons of blooms out of Moriah ore.

426. Highland Bloomary, on Howard Brook, at the outlet of Warm Pond, one mile west of Lake Champlain, seven miles south of Keesville, owned and managed by A. G. Forbes, Port Kendall P.O. Essex county New York, was built about 1837, has 2 bloomary and 1 forge fire with 1 hammer driven by water, and has made about 100 tons of blooms per annum out of Moriah magnetic ore.

427. **Port Kendall Bloomary,** one mile east of Highland Forge last described, was abandoned many years ago.

428. Purmort's Bloomary, on the south branch of Ausable river in the village of Jay, in Essex county New York, six miles south of Ausable Forks, owned and managed by J. H. Purmort & Company, built in 1809 and rebuilt in 1857, has 4 bloomary and 1 forge fire with 1 hammer driven by water, and made in 1855 about 500 tons of blooms out of Arnold's magnetic ore.

428.5. Two forges, small and doing but little, situated above "Purmort's," on the same stream, were destroyed by the same freshet, and will not be rebuilt.

429. Ausable Bloomary, on the south bank of West Ausable river, twelve miles west of Keesville, and in the village of Ausable Forks, Essex county New York, is owned and managed by J. & J. Rogers, was built in 1848, has 4 bloomary and 6 forge fires with 1 hammer driven by water, and made in 1856 912 tons of blooms out of Palmer's magnetic ore.

430. Upper Blackbrook Bloomary, on the east bank of Blackbrook, in Blackbrook village, Clinton county New York, four miles northwest of Ausable Rolling Mill, is owned and managed like the last described, was built in 1832, rebuilt in 1855, has 4 bloomary and 2 forge fires with 1 hammer driven by water and made in conjunction with the next in 1855 2,525 tons of blooms out of magnetic ore.

431. Lower Blackbrook Bloomary, situated and owned like the last, was built in 1832 and enlarged in 1857, has 8 bloomary and 4 forge fires with 2 hammers driven by water, and made in 1856 (in connection with the last) 2,189 tons of blooms out of magnetic ore.

432. New Sweden Bloomary, on the north bank of Ausable river, two miles west of Clintonville, owned and managed by William V. K. McLean, New Sweden P.O. Clinton county

New York, was built in 1822 and rebuilt in 1846, has 2 fires and 1 hammer driven by water, made in 1854 280 tons of blooms out of Jackson's & Nelson's ores, and has made nothing since. The great freshet of October 1846 did it much damage.

432.5. **A Forge,** erected in 1844 by Philip T. Brewster, stood nearly opposite the New Sweden Works, and was run till 1853. The great freshet of 1856 removed every vestige of the works. The last occupants were Messrs. Brockway and Brigham; it had 2 fires and 1 hammer, and made in 1852 about 200 tons of iron out of Arnold & Nelson magnetic ore.

433. **Upper Clintonville Bloomary,** in the village of Clintonville, Clinton county New York, on the north bank of the Ausable river, six miles west of Keesville, owned by Saltus & Company, 7 Beaver street New York city, has 4 fires, is driven by water and makes blooms out of magnetic ore.

434. **Lower Clintonville Bloomary,** situated owned and driven like the last, has 15 fires.

435. **Cook's Bloomary,** in the village of Cocksackie, Clinton county New York, on the Little Sable river, was last worked by Kingsland of Keesville, had 4 fires, and is abandoned.

436. **Honsinger's Bloomary,** in Peaseville, Clinton county New York, on the Salmon river, five miles southwest of Norrisville, is owned and managed by A. W. Honsinger Schuyler's Falls P.O. was built in 1845, rebuilt in 1856, has 2 bloomary and 1 forge fire with 1 hammer driven by water and made in 1855 about 200 tons of blooms out of Tremble's magnetic ore.

437. **Upper Norrisville Bloomary,** on the north bank of the Salmon river, two and a half miles west of Schuyler's Falls P.O. Clinton county New York, is owned and managed by Albert Norris, was built in 1857, has 2 fires and 1 hammer driven by water and makes blooms out of magnetic ore.

437.5. An old disused forge which occupied this site was destroyed by the freshet of 1856.

437.6. An old forge standing forty rods above the last mentioned, lay idle two years before the freshet of 1856. A saw-mill now occupies its site.

438. **Norrisville Bloomary,** situated, owned and managed like the last, was built in 1822, rebuilt in 1848 and 1856, has 3 bloomary and 1 forge fire with 1 hammer driven by water, and made in 1855 531 tons of blooms out of Moriah magnetic ore.

439. Merchant's Bloomary, on the south bank of Salmon river, half a mile west of Schuyler's Falls P.O. Clinton county New York, nine miles south of Plattsburg, is owned by Henry P. Merchant and leased by Elisha Hare, has 2 bloomary and 1 forge fire with 1 hammer driven by water and made in 1856 230 tons of blooms out of magnetic ore.

440. Myers' Bloomary and Forge, on the west bank of the South Saranac, at the Forks village, Clinton county New York, is owned and managed by L. Myers & Son, Plattsburg P.O. was built in 1844 and rebuilt in 1853, has 6 bloomary and 2 forge fires, 1 heating furnace and 3 hammers driven by water, and made in 1856 601 tons of blooms, bars and axles.

441. Russia Bloomary, No. 1, on the south bank of the Saranac, one mile west of the Falls village, in Clinton county New York, is held by the assignees of Hewitt & Stoddart, has 4 fires and 2 hammers driven by water, made perhaps 1,000 tons of blooms and bars per annum previous to 1856, but is now abandoned.

442. Russia Bloomary, No. 2, situated like the last, but owned by G. & G. H. Parsons, Saranac P.O. Clinton county New York, was built in 1845, rebuilt in 1847, has 4 bloomary and 1 forge fire and uses 1 of its 2 hammers driven by water, making about 500 tons of blooms and bars per annum, out of magnetic ore from Tremble's bed and Redford.

443. Platt's Bloomary, situated in Saranac village, on the north bank of the river, one mile east of Russia Bloomary last described and seventeen miles west of Plattsburg, is owned by M. K. Platt, managed by D. C. Boynton, Saranac P.O. Clinton county New York, was built in 1845, has 4 bloomary and 1 forge fire with 1 hammer driven by water and makes about 800 tons of blooms per annum out of various surrounding magnetic ores.

444. Elsinore Bloomary, on the north bank of the Saranac river, one mile west of Cadyville, and twelve miles west of Plattsburg P.O. Clinton county New York, is owned and managed by A. Williams, was built in 1845, has 3 bloomary and 1 forge fire, uses 1 of its 2 hammers driven by water, and made in 1856 625 tons of blooms out of magnetic ore.

445. Danemora Bloomary Forge, within the inclosure of the State Prison pickets in the village of Danemora, Clinton

county New York, owned by the State and leased by E. & J. D. Kingsland & Company, was built in 1854, has 10 bloomary and 2 forge fires with 2 hammers driven by steam and made in 1856 about 2,000 tons of blooms out of magnetic ore mined in the inclosure.

446. Stone Bloomary, on the south bank of Saranac river, below Cadyville, ten miles west of Plattsburg, Clinton county New York, is owned by Eli Chittenden of Burlington Vermont, and managed by Josiah Hayden, has 6 fires and 1 hammer driven by water, and made in 1854 about 600 tons of blooms and bars, but nothing since, out of State Prison magnetic ore.

447. Weston Bloomary, in the town of Plattsburg, on the Saranac river, near its mouth, owned and managed by Z. N. Weston, Plattsburg, Clinton county New York, was built in 1856, has 6 fires and 3 hammers driven by water and makes about 300 tons of blooms per annum, out of Moriah magnetic ore.

448. Brasher Bloomary Forge, on Deer river, in Brasher Iron Works village, near the furnace, owned and managed by J. W. Skinner, Ogdensburg P.O. St. Lawrence county New York, was built in 1835, rebuilt in 1857, with 2 bloomary, 1 forge fire and 1 hammer driven by water, and made in 1856 about 75 tons of merchant bars, out of bog ore from Franklin county, and some scrap.

449. Brasher Centre Bloomary Forge, on St. Regis river, six miles from the Northern railroad and five miles from Brasher Falls P.O. St. Lawrence county New York, is owned and managed by Jonas Crapser, was built in 1849, has 3 bloomary fires, 1 forge fire and 2 hammers, driven by water, and makes about 35 tons of merchant bars per annum out of bog ore from the vicinity.

450. Norfolk Bloomary, near the last, has been abandoned these ten years and is in ruins.

451. Waddington Bloomary, on the St. Lawrence river in Madrid township St. Lawrence county New York, has been abandoned these ten years and is in ruins.

452. Fullerville Forge, alongside of the furnace, in the village of Fullerville, St. Lawrence county New York, owned

and managed by Fuller & Peck, was built in 1833, has 2 fires and 1 hammer driven by water, and makes about 50 tons of bars per annum out of pig metal and scrap iron.

453. **Westfield Forge,** in Franklin county New York, has been out of blast for a long time.

454. **Sterlingville Forge,** on Black creek below the furnace in the village of Sterlingville, Jefferson county New York, owned and managed by Caleb Essington, has 3 bloomary and 1 forge fire with 1 hammer driven by water, and makes about 40 tons of draught iron bars per annum out of scrap and pig.

455. **Jefferson Forge,** on the east bank of Black river, in the village of Carthage, Jefferson county New York, owned and managed by Hiram McCollom, was built about 1818, and rebuilt in 1847, with 3 fires and 1 hammer driven by water, and makes about 150 tons of blooms and bars per annum out of pig metal and some scrap iron.

456. **Felson's Forge,** on the south side of Castlemann's river, Milford township, on the line of the Turkey Foot turnpike, eight miles above the Turkey Foot, and fifteen miles south of Somerset, in Somerset county Pennsylvania, was going about 35 years ago. It hauled its pig metal across the Alleghany mountains from Bedford county.

457. **Scott's Forge,** on Laurel Hill creek in Jefferson Township, Somerset county Pennsylvania, two miles below Bakersville, on the Cumberland and Pittsburg Plank Road, also hauled its metal from Bedford, and was abandoned thirty years ago.

458. **Fairchance Forge,** attached to the Furnace and Rolling Mill, eight miles south of Uniontown, Fayette county Pennsylvania, has been owned by F. H. O. Oliphant for twenty years and by his father for forty years previously, and worked up the pig iron of the furnace before the rolling mill was built.

459. **Brownsville Forge,** in Brownsville, Fayette county Pennsylvania, once owned by G. W. Cass & Company, is very old and was abandoned some years ago.

459.2. **Pennsylvania Forge,** in Pittsburg one mile above the Moyamensing Bridge, owned by Everson, Preston & Company, office 94 Water street Pittsburg, Alleghany county Pennsylvania, was built in 1844, has about 11 puddling, 8 heating furnaces, and 2 hammers, one a Nasmyth, driven by steam, and made shapes as well as bar iron. See Rolling Mill Table J. No. 158.

459.4. **Sheffield Works,** in South Pittsburg, owned by Singer, Hartman & Company, 82 Water street, has 4 puddling and 9 heating furnaces, 5 converters, 6 forge fires for making

charcoal blooms and 2 hammers. It makes vices, axles, axes, springs, etc. See Rolling Mill Table J. No. 156.

459.6. Duquesne Works, in Pittsburg, owned by Coleman, Heilman & Company, 121 Water street, is a rolling mill (see J. 165), but has 3 hammers.

459.8. West Point Forge, owned by D. Fawcet & Company, makes heavy shafting and every variety of shapes like the Pennsylvania Forge, and with the latter is reported to have consumed in 1857 (S. H. Thurston) 1,950 tons of bar iron and 220,000 bushels coal, employing 57 men and producing $224,500 worth of work. Besides these, the Eagle and Lippincott Works (see Rolling Mill Table J. 157, 162), Postley, Nelson & Company's, 22 Market street, founded in 1843, and the Empire Works, Newmyer & Graff, 22 Wood street, founded in 1854, manufacture shovels and axes, consuming in 1856 the four together 3,173 tons of bar and sheet iron, 570 tons of steel, 394,000 bushels coal and coke and make 44,000 dozen axes, 32,000 dozen shovels, 13,500 dozen picks and mattocks, 11,000 dozen planter's hoes, and 2,500 vices, besides saw blades. (Thurston.)

460. Sample's Forge, at Sample's Landing on the Ohio fifteen miles below Gallipolis, bloomed for McNichol's Mill at Covington opposite Cincinnati up to about 1842, when it was abandoned.

461. Benner's Forge, near Chilicothe, Ross county Ohio, on Paint creek, was once owned by James & Woodruff and has been abandoned for some years.

462. Steam Forge, at Steam Furnace on Brush creek in Adams county Ohio, was abandoned about twenty years ago.

463. Scioto Forge, in Adams county Ohio, perhaps five miles up the Little Scioto river, was managed by Mr. Wurtz in 1853 and had 3 refinery or knobling fires, 1 puddling furnace and 1 hammer.

464. Brush Creek Forge, in Adams, eight miles perhaps up Brush creek, was run at different times by Voorhies, Fisher & Means, and abandoned years ago.

465. Twelvepole Forge, at the Shoals of Twelvepole creek, six miles above Cerido on the Ohio in Greenup county Kentucky, was an old forge which has entirely disappeared.

466. Fulton Forge, on the south bank of the Ohio, three miles east of Greenupsburg, in Greenup county Kentucky, was built about 1830 by Paull, Shreve & Company, with about 12 knobling fires, made Bellefonte Furnace pig into Cincinnati blooms, and was abandoned about 1847.

467. Enterprise Forge, six miles west of Greenupsburg, in Greenup county Kentucky, once run by Clingman, with 4 knobling fires, was an old and important iron-works in its day.

468. Shreeve's Forge, one mile south of Greenupsburg, in Greenup county Kentucky, at the falls of Little Sandy, was an old works, and abandoned many years ago.

469. East Fork Forge, six miles south of Greenupsburg, in Greenup county Kentucky, on East Fork of Little Sandy, was an old works long ago abandoned.

470. Argolite Forge, eight miles south of Greenupsburg, in Greenup county Ky., at Argolite Furnace on the Little Sandy, was abandoned twenty years ago.

471. Ward's Forge, fourteen miles south of Greenupsburg, in Greenup county Kentucky, at Pactolus Furnace on Little Sandy, was abandoned many years ago.

471.5. Old Hopewell Forge, in Greenup county, abandoned.

472. Beaver Forge, sixty miles south of Greenupsburg, on Licking river, in Estill county Kentucky, was abandoned many years ago.

473. Red River Forge, in Estill county Kentucky, at the Rolling-mill on Red river, twenty miles north of Irvine and thirty-eight east of Lexington, was built about 1810, has 3 knobling furnaces and 1 hammer driven by water, and makes about 250 tons of bars per annum.

474. Nolin's Iron Works, in Edmondson county Kentucky, sixty miles southwest of Louisville, at the east end of the West Kentucky coal-field, was abandoned years ago.

475. Elizabeth Forge, in Crittenden county Kentucky, two miles northeast of Dycusburg, owned by G. D. Cobb, is an old works, abandoned.

476. Union Forge, on the right bank of the Cumberland river, three miles from Suwannee Furnace, two miles below Eddyville, in Lyon county Kentucky, owned by Kelly & Company, and managed by John B. Evans, was built about 1840 and rebuilt in 1854, has 8 knobling fires and 1 hammer driven by steam, and made in 1856 about 1,000 tons of blooms out of pig iron.

477. Tennessee Iron Works, on the right bank of the Cumberland river, ten miles above Eddyville, in Lyon county Kentucky, owned by Hillman, Brothers, and managed by George Hillman, was built in 1846, has 22 knobling or refining fires, 1 puddling furnace and 1 hammer driven by steam, and made in 1856 3,384 tons of blooms out of pig metal with a little scrap.

478. Randolph Forge, connected with Dover Furnace No. 2 (K. 575) and the Cumberland Iron Works (J. 207) by eight or nine miles of the finest cinder road in Tennessee, and situated six miles northwest of the latter, is owned by Woods, Lewis & Company, Cumberland Iron Works P.O. Stewart county Tennessee, and managed by A. P. Parrish, was built in 1852, has 2 forge and 18 knobling fires with 2 hammers driven by steam, and made in 1857 2,689 gross tons of blooms.

479. Biron Forge, on Wells creek, four miles northeast from Ashland Furnace, and three miles west of Bowling Green P.O. Stewart county Tennessee, is owned and managed by H. H. Hollister and Brother, was built about 1830, has 1 cupola run out, and 4 knobling fires with 2 hammers driven by steam, and made in 1856 about 300 tons of bars, plough-moulds, and other shapes.

480. Yellow Creek Forge, at Yellow creek Furnace, K. 580, in Montgomery county Tennessee, is owned by R Steel & Company, and managed by John McDaniel and A. Bingham, was built in 1840, has 4 knobling fires and 1 hammer driven by water, and made in 1857 410 tons of blooms out of pig metal.

481. Valley Forge, one and a half miles from the right bank of the Cumberland river, six miles southeast of Cross-creek Furnace, K. 571, is owned by Jordan, Brother & Company, Clarksville P.O. Montgomery county Tennessee, was built in 1852, has 1 forge and 7 knobling fires with 1 hammer driven by steam, and made in 1857 1,050 gross tons of blooms out of pig iron.

482. Blooming-Grove Forge, on Bloom creek, two miles from the right bank of the Cumberland river, and three miles northeast of Valley Forge last described, is owned by S. R. Cook & Company, New York P.O. Montgomery county Tennessee, is very old, has 1 forge and 6 knobling fires with 1 hammer driven by steam, and made in 1857 1,009 gross tons of blooms out of pig metal. It is about to be abandoned.

483. Water Forge, on Barton's creek in Montgomery county Tennessee, four miles northwest of Henry Clay Forge next described, and owned by Jackson, McKiernan and Company, was

built in 1808, has 1 forge and 5 knobling fires with 2 hammers, driven by water and has done very little since 1853.

484. Henry Clay Forge, one mile back from the left bank of the Cumberland river, twenty miles south of Clarksville, and owned and managed by Theodore Hicks Baxter, Barton's Creek P.O. Dickson county Tennessee, was built about 1837, has 1 forge and 7 knobling fires with 1 hammer driven by steam, and made in five months of 1856 600 tons of blooms from pig metal.

485. Patterson Forge, is situated at a remarkable bend in the Harpeth river (a branch of the Cumberland from the south-west), where, after seven miles of current, it returns to within two hundred feet of its bed. This point is by road twelve miles from the mouth of the Harpeth in the Cumberland, but twenty-three miles by water. It is owned by James L. Bell and managed by A. W. Turner, Chestnut Grove P.O. Cheatham county Tennessee, has 1 forge and 8 knobling fires with 3 hammers driven by water, and makes Cincinnati blooms out of Worley Furnace pig metal (K. 593.)

486. Turnbull Forge, on Turnbull creek eighteen miles east of Worley and six miles east of Jackson Furnaces, twenty-five miles west of Nashville, was built 1815 by Richard, and rebuilt 1847 by Elias Napier, stopped in 1855 and will never run again. It is owned by William C. Napier, Charlotte P.O. Dickson county Tennessee, had 1 forge and 4 knobling fires with two hammers driven by water, and made in 1855 210 tons of blooms out of Cumberland Furnace pig metal. K. 590.

487. White Bluff Forge, on Turnbull creek, five miles above the last, two miles east of Jackson Furnace, fourteen miles south of Charlotte, and twenty-nine miles south of Nashville, is owned by Kurr & Hutchison, and managed by John Hall, Charlotte P.O. Dickson county Tennessee, was built in 1828, has 1 forge and 6 knobling fires with 2 hammers driven by water, and made in 1855 173 tons of blooms and bars out of Piney Furnace pig metal K. 594. It is now abandoned.

488. Hurricane Forge, on Hurricane creek, five miles north of Duck river and nine miles southeast of Waverly in Humphreys county Tennessee, is owned by George Hillman of the Empire Iron Works in Lyon county Kentucky, was built in 1839, had 1 forge and 4 knobling fires and 1 hammer driven by water, and made bars until it was abandoned, some time before 1854.

489. Big Creek Bloomary, six miles south of West Smithville T. 16, R. 4, Lawrence county Arkansas, owned by Alfred Bevens & Company, Calamine P.O. was built in 1857 with 2 fires and 1 hammer driven by water, and makes 250 lbs. of

swedged iron per day with cold blast, out of brown hematite ore.

490. Valle Forge, on Wolf creek three miles east of Farmington on the plank road from Iron Mountain to St. Genevieve, seventeen miles north of east from the Iron Mountain, is owned by Prewitt & Patterson and managed by John Patterson, Farmington P.O. St. Francis county Missouri, was built in 1852, has 9 bloomary and 9 knobling or refinery fires with 2 hammers driven by steam, and makes boiler slabs out of magnetic ore.

491. Pilot Knob Forge, near the Furnaces K. 606, owned by the same Company and managed by J. B. Bailey, Pilot Knob P.O. Iron county Missouri, was built in 1849 with 8 bloomary and 2 knobling fires and 2 hammers driven by steam. It stopped in 1855 and will probably never run again.

492. Maramec Forges, on the Spring branch of the Maramec river at the Furnace K. 612, is leased and managed by William James, Maramec P.O. Crawford county Missouri, was built in 1847, has 6 knobling fires and 3 hammers driven by water, and made in 1857 821 tons of blooms and 198 of bars.

493. Collins Iron Works, three miles west-northwest of Marquette, Marquette county Michigan, on Lake Superior, in T. 48 north, R. 25 west, sec. 9 on Dead river, in the village of Collinsville; is owned by the Collins Iron Company, C. A. Trowbridge Treasurer and Secretary, Detroit, Michigan; was built in 1855, has 8 bloomary fires and 2 hammers driven by water, and makes about 450 tons of blooms per annum out of Lake Superior magnetic ore.

494. Forest Iron Works, near Marquette, owned by the same company as the last, Peter White mortgagee, has 3 bloomary fires and uses magnetic ore.

495. Jackson Iron Works, near Marquette, and owned by the Jackson Iron Company, is not in operation.

496. Utah. A forge is reported in Utah, smelting iron ore found in the mountains east of Salt Lake City, but no reliable information could be obtained respecting it. Those mountains must abound in metamorphic ores of a fine quality, as well as in brown hematites and bog ores. Lower Silurian rocks have

been discovered in the Black Hills surrounding the metamorphic or azoic rocks, which, in Missouri, Wisconsin, and Michigan, contain such an abundance of iron. The coal measures appear near Fort Laramie and elsewhere, probably with their iron ores.

497. California. One or more forges are spoken of on the west coast, but nothing is known of them. The ores are those of metamorphic rocks of old but doubtful age.

TABLES D. G. J.

ROLLING MILLS IN THE UNITED STATES.

1. Pembroke Rolling Mill, situated in Pembroke, Washington county Maine, eleven miles west of Eastport, William E. Coffin, of Boston, treasurer; Lewis L. Wadsworth, superintendent, has 20 furnaces in all, 4 trains of rolls, 27 nail, 1 spike and 2 rivet machines driven by water, and made in 1856 about 4,500 tons of bar iron, nails, spikes and rivets.

2. Danvers Rolling Mill, situated two miles northwest of Salem, Essex county Massachusetts, on the main road to Danvers Neck and village, and owned and managed by C. A. Smith, is perhaps fifty years old, was enlarged in 1831, has 4 heating furnaces and 2 trains of rolls driven by steam, and makes up Swedish iron and old rails into shapes and rods. It ceased making nails about 1850.

3. **Glendon Rolling Mill,** situated at East Boston, Norfolk county Massachusetts, was a large and new establishment of the first class, and manufactured in ten months of 1854 7,649½ tons of rails. The machinery has been sold off and the works abandoned.

4. Bay State Rolling Mill, situated on the shore of South Boston, east of the Blind Asylum, Suffolk county Massachusetts, owned by the Bay State Iron Company, and managed by Ralph Croker of South Boston, was built in 1847 and remains unchanged, having 12 double puddling furnaces, 12 heating furnaces and 4 trains of rolls driven by steam and a new steam hammer, and made in 1856 17,872 tons of rails, out of Port Henry pig iron and old rails.

5. Norway Iron Works, in South Boston, Suffolk county Massachusetts, lately owned by the Norway Iron Company, managed by Mr. Gogan, has 4 heating furnaces and 1 train of rolls, driven by steam, and makes about 2,500 tons of rod iron per annum.

Table D

6. **Weymouth Rolling Mill,** four works in one, situated in East Weymouth, Norfolk county Massachusetts, owned by the Weymouth Iron Company, Nahum Stetson treasurer and agent, Bridgewater Massachusetts, was built in 1836. No. 1 stands on the issue of Whitman's pond to Back river; Nos. 2 and 3 on Back river, on each side of the South Shore railroad at some distance from it; and No. 4 in Wingham, Plymouth county, just across the line. The nail factory at the wharf, No. 3, was erected in 1841. The works have 21 furnaces in all, and 89 nail machines, driven by water power, besides 3 forge fires and 3 hammers (forging a hundred tons of iron a year), and made in 1856 4,100 tons of nails, out of pig iron, castings and scrap.

7. **East Bridgewater Rolling Mill,** situated a quarter of a mile west of Abingdon and Bridgewater Cross Branch railroad (which joins the Old Colony and Fall River railroads) at the depot, 3 miles north of Bridgewater Junction, Plymouth county Massachusetts, and owned by Philips & Sheldon, 269 Commercial street Boston, were built about 1836, have 6 furnaces, 2 trains, 32 nail machines, 2 forge fires and 1 hammer, driven by water, and made in 1856 *perhaps* 1,400 tons of nails and tack plate iron.

8. **Bridgewater Rolling Mill,** situated on the Abingdon and Bridgewater Cross Branch railroad, one mile from Bridgewater village, Plymouth county Massachusetts, owned by Lazell, Perkins & Company, Nahum Stetson agent, was built about 1785, has 14 furnaces in all, 3 trains of rolls, 44 nail machines, 9 fires and 5 hammers (one a three-ton Nasmyth) in the forge, driven by steam and water, and makes perhaps 2,000 tons of nails, machinery forging, etc. per annum.

9. **Russell & Co.'s Rolling Mill,** situated in Plymouth, on the stream from Billington's Sea, Plymouth county Massachusetts, owned by Nathaniel Russell & Company, and managed by N. Russell, was built in 1807. The Plymouth Mills Co. Rivet Mill situated on the same water a quarter of a mile higher up, was built in 1845, and draws its rivet rods cold, making about 225 tons of rivets per annum; Mr. Russell, Jr. is agent, has 5 furnaces in all, 3 trains, 23 nail machines and a four-ton trip hammer, driven by water, and made in 1856 400 tons of

nails. Seven years ago the same company owned the Eel River Nail Works (four miles south, now a Duck factory) also, and made in both 30,000 casks of nails.

10. Tremont Rolling Mill, situated at the junction of the Cape Cod railroad and its branch to New Bedford, five miles north of Wareham and forty-six miles from Boston, in Plymouth county Massachusetts, is owned by the Tremont Iron Company, Andrew S. Nye, superintendent. An old nail factory stood here. The present company raised the dam to 25 feet and re-erected the works in 1843. It has 23 furnaces in all, 3 trains of rolls, 90 nail machines, driven by water power, and made in 1854 4,707 tons of nails, hoops and a few shapes. It never made many shapes. A hoop mill is attached, which ran for a time but has done nothing for more than a year.

11. Weweantit Rolling Mill, No. 1, situated one quarter mile west of Weweantit Depot, Cape Cod railroad, 4 miles north of Wareham village or "Narrows," and one mile south of Tremont junction of New Bedford Branch in Plymouth county Massachusetts, owned by Lewis Kenney, J. H. Hall, George Gibbs, J. H. Kenney, and managed by Lewis Kenney, is known by its old name of Toby's Mill, was built in 1854, has 5 heating furnaces, 2 trains of rolls and 32 nail machines, driven by steam and water, and made in 1856 2,061 tons of nails out of blooms prepared in No. 2.

12. Weweantit, No. 2, situated on the shore at Wareham Narrows, one quarter mile south of Wareham depot, was a revival and new location in 1854 of some very old works back of No. 1, and has 2 double puddling furnaces, 1 train of rolls, and a hammer driven by steam, and made in 1856 about 1,200 tons of blooms out of pig iron and some scrap. Connected with it is a foundry and heavy machine shop, at which Winslow squeezers, etc., are made.

13. Parker Rolling Mills, situated, No. 1, the Railworks, at the depot, one mile from Wareham; No. 2, the rolling and puddling works, two miles north of the depot (where Mr. Boyd superintends), in Plymouth county Massachusetts, Caleb Sprague agent. The two mills have 16 furnaces in all, 3 trains and 84

nail machines, driven by water power, and made in 1856 330 tons of cut nails and spikes.

14. **Agawam Rolling Mill,** situated a furlong north of Agawam depot on the Cape Cod railroad, in Plymouth county Massachusetts, and owned by the Agawam Nail Company, Samuel T. Tisdale of New York owner and manager, was built in 1836, rebuilt in 1842, enlarged in 1849, at which time the Glen Rolling Mill was added. This lies two and three-quarter miles further north, and was intended merely to increase the make; it has not been used for nearly a year. Both use the water from Halfway pond, a large natural reservoir. The mills have 15 furnaces in all, 3 trains of rolls and 80 nail machines, and made in 1854 3,600 tons of nails out of pig iron and some blooms and scrap.

15. **Kinsley Iron Works,** in Canton, Norfolk county Massachusetts, at the end of the Canton branch of the Providence railroad eighteen miles south of Boston. There is a foundry, a machine shop and a forge, with six hammers attached to the mill.

16. **Old Colony Rolling Mill,** situated part in Taunton, part in Raynham, on two sides of the Taunton river and New Bedford branch of Providence railroad, four miles southeast of Taunton village, in Bristol county Massachusetts, and owned by the Old Colony Iron Company, Crocker & Co., was built in 1820. The present works, erected in 1844, consist of a nail plate rolling mill, a tack plate rolling mill, a hoop mill not in use, a nail factory, and a shovel factory. They contain 16 furnaces in all, 3 trains of rolls, and 96 nail machines, driven by steam and water power, and made in the fiscal year of 1855–6 106,000 kegs of nails, 6,223 dozen shovels, 1,100 tons of tack and shovel plate, and 195 tons of hoop iron, out of puddled pig iron, with some puddled scrap and foreign bar.

17. **Gosnold Rolling Mill,** situated at the upper end of New Bedford city at the extremity of Second street, owned by the Gosnold Mill Company, William Philips of New Bedford treasurer, Lemuel Kullock general superintendent, Bristol county Massachusetts, commenced running in 1856, has 4 furnaces and

3 trains of rolls, driven by steam, and made 1,030 tons chiefly hoop iron, and 100 tons of shapes, and will make wire.

18. Mount Hope Rolling Mill, situated five miles north of Fall river, in Bristol county Massachusetts, owned by Fairbanks & Field of Taunton, Job Leonard agent, was built in 1857, has 4 furnaces, 2 trains, and 40 nail machines, and is driven by steam.

19. Fall River Rolling Mill, situated in Fall River, at the foot of the hill below the depot, in Bristol county Massachusetts, Richard Borden treasurer and agent, was built in 1822, moved and rebuilt in 1842(?) and enlarged in 1846(?). It has 29 furnaces in all, 5 trains of rolls, and 102 nail machines, driven by steam and water, and made in 1857 7,880 tons of nails, rods, hoops and plates out of pig iron and more than half as much scrap iron.

20. Providence Rolling Mill, situated at the corner of India street, the south point of the City of Providence, one mile from the depot on the west side of the river, O. A. Washburn Junior agent, Providence Rhode Island, was built in 1845 for a rail mill by the New England Company. It made rails until 1848, when the Providence Iron Company was incorporated and turned into a spike and nail mill. It has 20 furnaces in all, four trains of rolls, and 66 nail machines driven by steam, and made in 1856 4,300 tons of cut nails and spikes out of Philadelphia pig iron and half as much scrap.

21. American Rolling Mill, opposite the Providence Rolling Mill last described, where the rolling and heating for this mill is done while it occupies itself with making the nails. It is owned by the American Horse Nail Company, William Tolman & Co. agents, Providence, Rhode Island. It makes about 175 tons of nails per annum.

22. Quinsigamund Rolling Mill, situated on the Providence and Worcester railroad, two miles from Worcester, and on Blackstone river at the forks in Worcester county Massachusetts, and owned by the Quinsigamund Iron Company, Charles F. Washburne agent, was built in 1847, has 3 heating furnaces, 3 trains of rolls and 30 blocks or frames for drawing wire cold, driven by steam and water, and has made 300 tons of hoop,

250 of rod, 3 tons a day of wire or 1,000 a year, the average of three years past, with very little fluctuation and no loss of time; out of American scrap iron mixed with a little northern New York bloom and a little Pennsylvania bar.

23. Cold Spring Rolling Mill, situated one and a quarter miles below Norwich City on the west side of the Thames river in New London county Connecticut, and owned by J. M. Huntingdon & Company, J. Mitchell superintendent, was built in 1842, burnt and reërected in 1846, has 3 heating furnaces and 3 trains of rolls, is driven by water power, and made in thirty-eight weeks of 1856 1,143 tons of small iron out of scrap entirely.

24. Ripley Rolling Mill, situated at Windsor Locks on the Connecticut river and canal, twelve miles above Hartford, and a furlong south of the railroad depot, in Hartford county Connecticut. Philip Ripley of Hartford, owner; T. G. Nock, lessee; G. Nock, manager, was built in 1847, and had three converting steel furnaces added in 1849 and 1851 to make blister and spring steel. It has 6 furnaces in all and 3 trains of rolls, driven by water power, and made in 1855 480 tons of nail rods, shoe shapes, tack plates, and various sizes of rod iron and corking steel principally out of Swedish iron.

25. Birmingham Iron and Steel Works, situated opposite the Naugatuck railroad, Derby station, one-quarter mile west, across the river in New Haven county Connecticut, Mr. Woltwater secretary, Mr. Hawkins superintendent, has 11 furnaces in all and 4 trains of rolls, driven by steam and water, with a machine shop, making 4 tons of axles and 4 tons of springs a day, and a steel convertory, making 30 tons of steel in ten days. In 1855 and 6, it made 819 tons axles, 677 tons springs, 1,356 tons merchant iron, 520 tons spring steel.

26. Stillwater Iron Works, situated on Mill river two miles north of the village, was originally a forge and afterwards an axe factory. Its wire mill is three miles further up the same stream in Fairfield county Connecticut, owned by the Stillwater Iron Company and managed by Mr. Wicks, was built in 1835, has 4 furnaces in all, and 2 trains of rolls, driven by steam and water, 2 steel converting fires, and 1 steel train,

and made in 1856 about 1,100 tones of brazier and wire rods, out of principally borings and shavings.

26.5. There was once a mill in Stamford village, but some years ago it was converted into a foundry, and last year all the flasks and machinery were sold and the place abandoned.

27. Greenwich Iron Works, situated on a stream three miles west of Stamford village in Greenwich township, owned by Holden & Company, and managed by Mr. Hicks, Mianus P.O. Fairfield county Connecticut, was built in 1836 and always has been a rolling mill and with little alteration. It has 6 furnaces in all and 4 trains of rolls, driven by water power, and made in 1856 1,440 tons of nail rods, wire rods, merchant iron, square spike iron and stove rods, out of chiefly Norway bar, mixed with New Jersey pig, cast-iron borings and a few blooms, Juniata billets and a little scrap.

28. Fairhaven Rolling Mill, situated on the Whitehall and Rutland railroads, sixteen miles west of Rutland, and six miles west of the Castleton junction with the Rutland and Washington railroad, and in front of the village of Fairhaven in Rutland county Vermont, is owned by Israel Davey and was built about 1820. Here has been an old nail mill for 30 or 35 years and a forge run by the late Mr. Davey, now by his son Israel Davey. The rolling mill makes nail plates, marble saw-blades, horse-shoe rods and a little merchant iron out of the hammered bars which the bloomary forge alongside makes from St. Lawrence or Champlain ore. The small nail factory attached contains 3 furnaces, 1 five-pair train, 6 nail and 1 six-inch spike machine, and makes 1,000 kegs of nails a month or about 500 tons of nails per annum.

29. Rensselaer Rolling Mill, situated on the south end of the city of Troy, between the railroad and the river, and owned by the Rensselaer Iron Company, John A. Griswold, Troy, Rensselaer county New York, agent, was started in 1847 and converted to a rail mill in 1853 with 18 furnaces in all, and 4 trains of rolls driven by steam, and made in 1856 12,650 tons of rails and 862 tons of merchant bar out of one-third pig metal and two-thirds foreign iron.

30. Albany Iron Works, situated near the Hudson river and Iron Works station of the Greenbush and Troy railroad at

the mouth of the Wynantskill, two miles south of Troy in Rensselaer county New York, and owned by Corning, Winslow & Company, J. H. Jackson agent, was built in several parts at different times, has 40 furnaces in all, 8 trains of rolls, 60 nail, 11 spike, 2 rivet machines, and 2 hammers for railroad axles, and a machine for wrought-iron chairs. No. 1 is the main steam mill, with 7 steam-engines of 250 aggregate horse-power. No. 2 the star forge in the form of a Greek cross, has 2 steam-engines, shops, etc. No. 3, the old mill rebuilt, has water power, and makes steel, axles, sleigh-shoes, and crow-bars. The works consume 4,000 tons of Lake Champlain magnetic ore for puddling; employ 600 men; have 3 dams on the Wynantskill, and 5 wheels; produced in 1856 11,566 gross tons from the crude material, spikes of all sizes, railroad axles, railroad iron, wrought-iron chairs, carriage axles, rolled iron, bar and spring steel, crow-bars, boiler-rivets, cut-nails and steel sleigh-shoes.

31. Burden's Rolling Mill, situated on the Wynantskill, half a mile east of the Hudson, two miles south of Troy, in Rensselaer county New York, and owned by Henry Burden, William F. Burden agent, has 24 furnaces in all, 7 trains of rolls, 33 nail and 1 horse bending and moulding machine, and a remarkable breast-wheel, 60 feet in diameter and 22½ feet in face, and made in 1856 8,700 tons of merchant bar iron, nails, etc., out of principally pig iron, with some bloom and scrap.

32. Ulster Rolling Mill, situated on the west bank of the Hudson, at Saugerties, opposite Tivoli station, twenty-two miles above Rhinebeck, in Ulster county New York, owned by J. & L. Tuckerman, 106 Washington street New York city, and managed by John Simmons, was built in 1825 or 1826, and greatly damaged by the freshet of 1857, has 22 furnaces in all, 5 trains of rolls, and 1 English hammer of five tons weight driven by water power, and makes perhaps 4,000 tons of merchant bar iron, car tyre, etc., per annum.

33. Ramapo Iron and Steel Works, opposite Ramapo station, Erie railroad, Rockland county New York, owned by Henry L. Pierson, 24 Broadway New York city, and other heirs of Jeremiah G. Pearson, and leased by J. Wilson, was built about the beginning of this century, and has 2 single puddling

furnaces, 12 double cast-steel furnaces, 3 converting furnaces, 2 trains of rolls and a trip hammer driven by water power, with 2 bloomary fires built in 1850. All its iron is remade into cast-steel—about 150 tons in 1856.

34. Suffern's Rolling Mill, on the west side of the Ramapo river, owned by Andrew Winter, Ramapo P.O. Rockland county New York, was previous to 1853 a bloomary forge, built about 1849, has 1 puddling furnace, 2 trains of rolls and 2 hammers, driven by water power, and makes about 300 tons per annum of merchant bar out of scrap iron.

35. Chrisman & Durben's Rolling Mill, one and a half miles west of Jersey City ferry, on Prospect street, owned by Chrisman & Durben, Hudson county New Jersey, started early in 1857, with 2 heating furnaces and 1 train of rolls, driven by steam, to make boiler plate for New York.

36. Chrisman & Co. Rolling Mill, two miles southwest of Jersey City on Bergen Point plank road, owned by Chrisman & Company, Jersey City Hudson county New Jersey, was built in 1852, has 2 heating furnaces and 1 train of rolls, driven by steam, and made in 1856 about 550 tons of boiler plate for New York and Richmond out of charcoal blooms and a little scrap.

37. Charlottenburg Rolling Mill (under the same roof with the Forge), eleven miles north of Rockaway, owned by George H. Renton, Newark, and managed by C. F. D'Camp, Newfoundland P.O. Morris county New Jersey, was built in 1840, has 2 heating furnaces and 3 trains of rolls, driven by water power, and made in half of 1857 174½ tons of finished merchant iron.

38. Pompton Rolling Mill, close by the Furnace, six miles east of Rockaway, Morris county New Jersey, owned by Charles A. Richter of Boonton and leased by Illingworth, Nimmo & Company, was built in 1838 and enlarged in 1844 by Horace Gray. It has 10 furnaces in all, 3 trains of rolls, 3 cast-steel fires, and a hammer, and made in 1856 perhaps 100 tons of steel, and nothing else until it recommenced work in 1857.

39. Powerville Rolling Mill, four miles east of Rockaway, T. C. Willis owner and manager, Boonton P.O. Morris county

Table G

New Jersey, was built in 1846, has 1 heating furnace and 2 trains of rolls, driven by water, and makes about 400 tons per annum of hoop and rod iron out of blooms.

40. Rockaway Iron Works, at the east end of the village of Rockaway, Morris county New Jersey, and owned by the Rockaway Iron and Steel Works Company, Moses A. Brockfield and Albert A. Stanborough of Morristown assignees. There has been here a small mill since 1826; last rebuilt in 1855, has 8 furnaces in all, 2 trains of rolls, 2 nail and 2 spike machines, and 3 hammers driven by steam and water, and made in 1855 about 2,000 tons of railroad spikes, etc., out of half charcoal blooms and half anthracite pig metal.

41. Boonton Rolling Mill, nineteen miles from Newark, owned by Fuller, Lord & Company, New York, W. G. Lathrop agent, Boonton P.O. Morris county New Jersey, was built about 1825, has 20 furnaces in all, 3 trains of rolls and 110 nail machines, driven by steam and water, and made in 42 weeks of 1857 7,372 tons of nails and spikes out of principally pig metal, with a large consumption of ore and scrap.

42. Dover Rolling Mill, two hundred yards north of the Morris and Essex railroad, Dover station, owned by Henry McFarland and managed by G. H. Hinchman, Dover, Morris county New Jersey, was built in 1792, rebuilt in 1819, and again in 1838, has 2 heating furnaces for iron and one for steel, 6 boiler-rivet machines driven by steam in a separate building; a third roof covers five trunks for converting steel, holding 20 tons each; a cupola furnace and an air furnace for casting, made in 1856 935 tons of steel and rivets out of Swedish and American iron, and has made as many as a thousand tons of steel in a year.

42.5. Monroe Nail Factory and Rolling Mill, stands in ruins and has not been used for thirty years.

43. Trenton Rolling Mill, on the Delaware river at South Trenton in Mercer county New Jersey, owned by Cooper, Hewitt & Company, of Burling slip New York city, was built in 1845, has 58 furnaces in all, and 6 trains of rolls, driven by steam, and made in 1856 14,000 tons of rails and wire. Here

were made the first "wrought-iron beams for fire-proof buildings" for the United States Government.

44. **Cumberland Nail and Iron Works,** at Bridgeton, thirty-five miles south of Philadelphia, owned by the Cumberland Nail and Iron Company, Robert C. Nichols manager, Bridgeton, Cumberland county New Jersey, was built in 1815, rebuilt in 1824, and enlarged in 1847 and 1853, has 20 furnaces in all, 2 trains of rolls and 102 nail machines, is driven by steam and water, and made in 1856 4,265 tons of bars, 83,337 kegs of nails, and 561,542 feet of gas tube.

45. **Lehigh Rolling Mill,** between the canal and the river, in South Easton, two miles above the mouth of the Lehigh river, owned by Stewart & Company and managed by John Stewart, South Easton, Northampton county Pennsylvania, was built in 1837, has 4 heating furnaces and 2 trains of rolls, driven by water, and made in 1856 42,680 bundles or 1,344 tons of wire, and in 49 weeks of 1857 1,197½ tons.

46. **Oxford Iron and Steel Works,** on Frankfort creek, five miles from Chestnut street, in the 23d Ward of Philadelphia, owned by W. & H. Rowland, office 61 South Second street Philadelphia, was built in 1855, has 4 heating furnaces, 2 trains of rolls and 2 hammers, is driven by steam and made in 1857 696 tons of spring and cast-steel scrap and foreign iron.

47. **Kensington Rolling Mill,** on Beech street above Poplar in Philadelphia, owned by Nat. Rowland & Company, was built in 1840 and rebuilt beside the Kensington Iron Works, has 2 heating furnaces and 1 train of rolls driven by steam, and made in 1855 about 1,300 tons.

48. **Kensington Iron Works,** alongside of the last, but owned by James Rowland & Company of Philadelphia, was built in 1845, has 19 furnaces in all, and 4 trains of rolls, driven by steam. Both works are said to have made in 1856 5,000 tons of spring, plough and shovel steel.

49. **Penn Rolling Mill,** on North Delaware avenue above Poplar street in Kensington, Philadelphia, owned by J. Robbins, junior, & J. P. Verree, and leased by Verree & Mitchell, was built in 1845, has 5 heating and 3 converting furnaces

capable of converting 1,000 tons of iron to steel, and 2 bloomaries for scrap and a hammer, driven by steam, and made in 1856 perhaps 1,800 tons of spring steel, plough steel, bar iron, slit rods and blooms out of principally scrap with some Swedish.

50. Treaty Rolling Mill, on Beech and Mulberry streets in Kensington, Philadelphia, owned by Leibert & Wainright, but leased by Marshall, Plunkett & Co., was built in 1846 for a rail mill but lay idle six years, and was fitted up in December, 1856, for a sheet mill, has 5 furnaces in all, and 2 trains of rolls, driven by steam.

51. Fairmount Rolling Mill, on Thirtieth street above Coates, back of the Fairmount Water Works in Philadelphia, owned and managed by Charles E. Smith, was built in 1846, between the Columbia railroad and the Schuylkill canal, has 11 furnaces in all and 2 trains of rolls, driven by steam, and made in 1857 2,378 tons of band, hoop and bar iron. Makes gas tubing, socket and railroad chair iron, and railway rails, out of pig iron.

52. Fountain Green Rolling Mill, situated on the east bank of the Schuylkill, half a mile below the Columbia railroad bridge, two miles above Fairmount in Philadelphia, owned by Strickland Kneass, office 56 Walnut street, J. Haldeman agent, H. McCarty junior manager, was built in 1848, has 8 furnaces in all, 2 trains of rolls, 19 nail machines, a railroad spike machine, a rivet machine with a heater, and a new horseshoe machine, 1 guide mill, 1 cut-spike and 1 railway chair machine, driven by steam, and made in 1855 1,655 tons of bar and rod iron and nails, principally out of pig iron with some scrap.

53. Flatrock Rolling Mill, owned by M. B. Buckley & Son, 56 Walnut street Philadelphia, and managed by Mr. Harrigan, is situated alongside of the forge (No. 80, Table F.), between the east bank of the river and the canal at the upper end of Manayunk, above the factories, and works up its blooms. Built in 1820, it has 1 heating furnace and 1 train of rolls driven by water power, and made in 1856 600 tons of plate. This mill was moved to, and rebuilt at Grey's Frry, below Philadelphia in 1858.

54. Pencoyd Rolling Mill, on the west side of the Schuylkill, half a mile below the Flat Rock, in Montgomery county, is

owned by A. & P. Roberts, office Walnut street Philadelphia, was built in 1855, has 2 heating furnaces and 1 train of rolls, driven by steam, and made in 1857 1,382 tons of axles and bar iron out of scrap.

55. Cheltenham Rolling Mill, on the Tacony creek, three-quarters of a mile above Milltown, two miles from Green Lane station, North Pennsylvania railroad, and one mile below Shoemakertown in Montgomery county Pennsylvania, owned by Rowland & Hunt, was built in 1790, has 2 heating furnaces and 1 train of rolls driven by water power, and makes perhaps 1,000 tons of boiler plate a year.

55.5. Schuylkill Iron Works, 12 miles from Philadelphia, owned by Alan Wood, L. A. Lukens, T. and A. Wood, jun., No. 38 N. Front street, was built in the beginning of 1858, with 2 puddling, 1 heating and 2 grate furnaces, and 2 trains of rolls, driven by steam, and with a capacity of 1,500 tons of sheet and plate iron per annum.

56. Conshohocken Rolling Mill, between the Schuylkill river and canal, thirteen miles from Philadelphia, in Montgomery county Pennsylvania, owned by John Wood & Brothers, office 159 North Second street Philadelphia, was built in 1832, and only uses now 1 heating furnace and one train of rolls, driven by water power, for finishing the Pennsylvania Rolling Mill work.

57. Pennsylvania Rolling Mill, situated and owned like the one last described, was started in 1853, has 10 furnaces in all and 3 trains of rolls, driven by steam, and both together made in 1856 184 tons of Russia sheet, 724 tons of puddled ditto, 100 tons of flue, and 132 tons of bloom sheet iron out of pig metal and some blooms. In 1857 1,230 tons.

58. White Marsh Iron Works, near the last two, and owned by Wood & Lukens, Conshohocken P.O. Montgomery county Pennsylvania, was built in 1857, has 4 furnaces and 2 trains of rolls, driven by steam, and makes imitation Russia sheet.

59. Norristown Rolling Mill, on the Schuylkill river front behind the anthracite furnace at the upper end of Norristown, in Montgomery county Pennsylvania, is owned by William Schall, was built in 1850, has 20 furnaces in all and 2

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trains of rolls, driven by steam power, and made in 1857 700 tons of boiler plate.

60. Norristown Nail Factory, No. 2, situated near the last, and owned by William Schall & P. Dewees, Norristown P.O. Montgomery county Pennsylvania, has 1 spike and 28 nail machines, and made in 1857 1,344 tons of nails.

61. Norristown Rolling Mill, No. 3, on the river, just south of the two works last described, and owned by James Hooven, of Norristown, Montgomery county Pennsylvania, was built in 1846, has 11 furnaces in all, 3 trains of rolls, 13 nail machines and one hammer, and makes about 2,500 tons per year of merchant bar and plate iron and nails out of pig metal.

62. Phœnix Rolling Mills, on the Reading railroad at the mouth of French creek on the Schuylkill river, owned by the Phœnix Iron Company, office in Franklin Building Walnut street above Fourth Philadelphia, and managed by John Griffin, Phœnixville P.O. Chester county Pennsylvania, consists of three mills, first erected in 1846. The west or rail mill, with 36 furnaces in all, and 3 trains of rolls driven by steam, made in 1856 18,592 tons of railway iron. The east mill, with 21 furnaces in all, and 2 trains of rolls driven by steam, and the north mill, with 17 furnaces in all, and 3 trains of rolls driven by steam, made together the same year 3,690 tons of bar iron, rods and axles, and railway chairs, and girder beams.

65. Chester County Rolling Mill, between the Reading railroad and the Schuylkill river, a hundred yards above the Phœnixville Station, Chester county Pennsylvania, was built in 1830 and then leased by the Workingmen's Iron and Nail Company, E. F. Pennepacker secretary, but the lease expiring June 3, 1854, the works have fallen into dilapidation.

66. Thorndale Rolling Mill, close to the Columbia railroad, one mile west from Gallagerville, and three miles west from Downingtown, Horace A. Beale owner and manager, Thorndale Iron Works P.O. Chester county Pennsylvania, was built in 1847, has 4 puddling furnaces, 2 trains of rolls, and 1 Nasmyth hammer, is driven by steam, and made in 1856 800 tons of plates.

67. Rokeby Rolling Mill, on Buck Run and on the Pennsylvania railroad, four miles south of Coatesville, Chester county Pennsylvania, owned by Abigail Fisler and managed by

J. G. Fisler, was built in 1795, uses 1 heating furnace and 1 train of rolls, driven by water power, and made in 39 weeks of 1856 360 tons of boiler plate out of blooms.

68. **Brandywine Rolling Mill**, at Coatesville, Chester county Pennsylvania, owned by the heirs of R. W. Lukens, and built in 1810, has 2 heating furnaces and 1 train of rolls, driven by water power, and made in 1856 789 tons of boiler plate iron.

69. **West Brandywine Rolling Mill,** at Wagontown, forty miles west of Philadelphia on the West Branch Brandywine creek, two and a half miles north of Coatesville, Chester county Pennsylvania, owned by Samuel Hatfield and managed by Benjamin R. Hatfield Wagontown P.O., was built in 1840 and enlarged in 1843, has 4 and uses 2 heating furnaces and 2 trains of rolls, driven by water power, and made in 1856 1,065 tons of boiler plate iron out of blooms made at the Juniata Iron Works, G. 108, with which these works are connected.

70. **Laurel Rolling Mill,** at the mouth of Buck Run, four and a half miles south of Coatesville, Chester county Pennsylvania, and owned and managed by Hugh E. Steele, was built in 1825 and rebuilt in 1856, after a long lease to James Penrose. In 1855 had 2 and used 1 heating furnace and 1 train of rolls, driven by water power, and made perhaps 750 tons of boiler plate.

71. **Viaduct Rolling Mill,** a furlong from Midway Station, under the Coatesville viaduct, where the Columbia railroad crosses Brandywine creek, consists of two mills owned by Steele & Worth, Coatesville P.O. Chester county Pennsylvania, one built in 1838, the other changed from water to steam in 1855, uses 2 heating furnaces and 2 trains of rolls, driven by steam and water, and has a hammer also, and made in 1856 1,170 tons of boiler plate out of blooms.

72. **Valley (formerly Caln) Iron Works,** on the West Brandywine creek, a mile northeast of Coatesville, Chester county Pennsylvania, is owned and managed by C. E. Pennock & Company, was built in 1837, remodelled and enlarged in 1854 and 1857, has 2 heating furnaces and 1 train of rolls, driven by water power, and made in 1856 about 900 tons of boiler plates out of blooms.

73. Hibernia Rolling Mill, four miles north of Coa esville, the Hibernia Forge, one mile from Wagontown, in Chester county Pennsylvania, owned by Charles Brooke, and leased by Brooke & Brother, Wagontown P.O., was built between 1833 and 1840, uses 1 of its 2 heating furnaces, has 1 train of rolls, driven by water power, and made in half of 1855 220 tons of boiler plate out of blooms and a little scrap.

74. Pleasant Garden (formerly Chester Co.) Iron Works, owned by D. McConkey, of Westchester, and managed by J. Scott, New London Cross Roads P.O. Chester county Pennsylvania, was built in 1845, and is said to have made previously to 1856, with 2 heating furnaces and 1 train of rolls, driven by water power, 350 tons of boiler plate per annum. The forge beside it is in ruins.

75. Pinegrove Rolling Mill, in Lower Oxford Township, on the Chester county side of Octoraro creek, opposite the forge, and sixteen miles southwest of the Penningtonville Columbia railroad station, is owned and managed by Enos Pennock, Oakhill P.O. Lancaster county Pennsylvania, was built in 1844, has 1 heating furnace and 1 train of rolls, driven by water, and has made about 250 tons of boiler plate per annum.

76. Pottsgrove Rolling Mill, upon the Reading railroad, near the Schuylkill river bank, at the lower end of Pottstown, in Montgomery county Pennsylvania, is owned and managed by Potts & Bailey, was built in 1846, has 6 furnaces in all, uses 1 of its 2 trains of rolls, is driven by steam power, and made in 1854 1,400 tons of boiler plate out of charcoal slabs and a little anthracite pig iron and scrap.

77. Pine Rolling Mill, on Manatawny creek, in Berks county, two and a half miles northeast of Douglassville Reading railroad station, is leased and managed by Joseph Bailey & Sons, Pottstown, Montgomery county Pennsylvania, was built in 1845, uses 1 of its 2 heating furnaces, and made in 1856 972 tons of boiler plate out of blooms.

78. Birdsborough Rolling Mill and Nail Works, situated, with Keystone Furnace, on Hay creek near its junction with the Schuylkill river, nine miles below Reading, and owned and managed by E. & G. Brooke, Birdsborough P.O. Berks county

Pennsylvania, were built in 1848, have 8 furnaces in all, 2 trains of rolls, and nail machines, driven by steam and water, and made in 1856 39,957 kegs of nails. Hampton Furnace is two miles up the creek, and belongs to the same parties. Four miles above is Seidel & Switzer's forge, and a mile further up are H. Seifert's forges and boiler plate mill.

79. Gibraltar Rolling Mill, on Alleghany creek, half a mile from its mouth, and just above Thompson's and Franklin Forges, Nos. 98, 99, 100, Table F. five miles south of Reading, and owned and managed by H. A. & S. Seyfert, Reading, Berks county Pennsylvania, was built in 1846, has 2 and uses 1 heating furnace, and 1 train of rolls, driven by water power, and made in 1856 650 tons of boiler plate out of blooms.

80. Reading Rolling Mill, on Seventh street, at the south end of Reading, in Berks county Pennsylvania, owned by Seyfert, McManus & Company, was built in 1836, has 12 puddling and uses 5 of its 9 heating furnaces, 3 trains of rolls, 33 nail, 2 spike and 2 rivet machines, driven by steam power, and made in 1856 2,843 tons of bundled and bar iron, and 1,770 of nails, spikes and rivets out of pig metal with some blooms and scrap.

81. Neversink (Bertolet's) Iron Works, in Reading, Berks county Pennsylvania, a hundred yards above the Harrisburg turnpike bridge across the Schuylkill river, is owned and managed by M. A. & S. Bertolet & Company, was built in 1845, has 7 furnaces in all, 2 trains of rolls, and a Kirk hammer, is driven by steam power, and has made about 2,000 tons of merchant bar and plate iron per year out of two-thirds pig metal and one-third scrap.

82. McIlvaine's Rolling Mill, in Reading, Berks county Pennsylvania, at the corner of Neversink and Eighth streets, was erected in 1857 by William M. McIlvaine, has 2 heating furnaces, 1 train of rolls, and 1 Nasmyth two-ton hammer, and is intended chiefly for locomotive iron, having a capacity of 1,000 and expected to make 800 tons per year.

83. Keystone Rolling Mill, in Reading, Berks county Pennsylvania, on Pine street between Second and Third, is owned and managed by Snell, Mullen, Banford & McCarty, has

9 furnaces in all, and a train of rolls brought from the dismantled Glendon Rolling Mill at East Boston, D. No. 3, driven by steam power, and intended to make heavy shafting, bridge bolt and locomotive iron. Previous to 1857 it was simply a forge (see Table F. No. 96).

84. **Franklin Rolling Mill,** on the Little Schuylkill, above Port Clinton, in Schuylkill county Pennsylvania, was built in 1849, owned by John Rausch, of Port Clinton, and destroyed by a flood in 1854. It only made 50 tons of bar iron in 1849.

85. **Pottsville Rolling Mill,** in Pottsville, Schuylkill county Pennsylvania, at the bend of the Schuylkill river, the end of the Reading railroad, and the southern limit of the anthracite coal field, is owned and managed by John Burnish & Company, was built in 1852 for merchant bar, but now has 17 furnaces in all, and 2 trains of rail rolls, driven by steam power, and made in 1856 3,021 tons of T rails of every size.

86. **Palo Alto Rolling Mill,** in Pottsville, Schuylkill county Pennsylvania, is owned by Haywood, Lee & Company, was built in 1855 and enlarged in 1857, has 9 furnaces in all, and 2 trains of rolls, driven by steam, and made in 1856 about 2,500 tons of railway and merchant iron and axles out of pig metal.

87. **Weissport Rolling Mill,** in Weissport, Lehigh county Pennsylvania, on the Lehigh river, was added to the Forge F. No. 149 in 1854 by Weiss & Wentz, with 2 puddling, and 1 heating furnace and 1 train of rolls, driven by steam, and made in 1856 about 200 tons of bar iron.

88. **Lackawanna Rolling Mill,** built on the north side of the Lackawanna creek, three hundred yards above, and on the same side as the furnaces (Nos. 109 to 112, Table A.), in two parallel buildings, at the upper end of Scranton, Luzerne county Pennsylvania, is owned by the Lackawanna Coal and Iron Company, James H. Phinney secretary, was founded in 1844, has 47 furnaces in all and 3 trains of rolls, driven by water power, and made in 1856 11,338 tons of T rail.

88.5. **Danville Rolling Mill,** Montour county Pennsylvania, formerly owned by S. P. Case (Davis, lessee), with 3 puddling furnaces and 2 trains of rolls, built in 1845, and sold by the sheriff in 1848, has made nothing since that year.

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89. Rough and Ready Rolling Mill, on the North Branch Susquehanna and canal, eleven miles east of Northumberland, and on the Catawissa railroad, is owned by Hancock & Foley, Danville, Montour county Pennsylvania, was built in 1847, has 14 furnaces in all and 2 trains of rolls, driven by steam, and made in 1856 5,259 tons of rails.

90. Montour Rolling Mill, No. 1, situated between the main road down the river out of Danville and the canal at the lower end of town, and owned by the Montour Iron Company and managed by J. P. & J. Grove, Danville P.O. Montour county Pennsylvania, was built in 1846, has 49 furnaces in all and 3 trains of rolls, driven by steam.

91. Montour Rolling Mill, No. 2, was added in 1854 and has 33 single puddling furnaces and 1 train of rolls, driven by steam. Both mills together made in 1856 17,538 tons of rails. It is in this mill that Mr. Grove has tried puddling by machinery with alleged success.

92. Duncannon Rolling Mill, on the Susquehanna at the mouth of Shuman's creek and on the Pennsylvania railroad, fifteen miles above Harrisburg, is owned by Fisher, Morgan & Company, John Wister manager, Duncannon, Perry county, was built in 1838, has 17 furnaces in all, 4 trains of rolls and 52 nail machines, driven by steam and water, and made in 1857 3,844 tons of merchant bar and nails, in 10 months.

93. Fairview Rolling Mill, back of Fairview, two miles above the Harrisburg bridge, on the west side of the Susquehanna river, is owned by J. Pratt & Son, and managed by Charles Wilbar, West Fairview P.O. Cumberland county Pennsylvania, was built in 1831, rebuilt in 1847, and enlarged in 1851, has 8 furnaces in all, 2 trains of rolls and 35 nail machines, driven by water, and made in 1849 1,500 tons of nails chiefly.

94. Central Rolling Mill, on the Pennsylvania railroad at the upper end of Harrisburg, Dauphin county Pennsylvania, owned and managed by Charles L. Bailey & Brothers, was built in 1853, has 4 furnaces in all and 1 train of rolls, driven by steam, and made in 1857 1,411 tons of boiler plate, out of blooms.

95. Harrisburg Rolling Mill, between the railroad and the canal, a quarter mile below the railway station in Harrisburg, Dauphin county Pennsylvania, is owned by J. Pratt & Son of North Middlebury Connecticut, was built in 1836 burnt in 1851 and rebuilt and is disused since 1853; has 2 heating furnaces, 1 train of rolls and 12 nail machines driven by steam, and used to make 18 tons a week of finished bar and 5 a day of nail iron.

96. Columbia Rolling Mill, half a mile northwest of the railway station, owned by Smith & Bruner, and managed by James A. Richards, Columbia, Lancaster county Pennsylvania, was built in 1854, has 7 furnaces in all, and 2 trains of rolls, driven by steam, and made in thirty-four weeks of 1856 1,066 tons of merchant bar and rod.

97. Safe Harbor Rolling Mill, situated on the Conestoga Slackwater Navigation, near the Susquehanna river, ten miles southwest of Lancaster, owned by Reeves, Abbott & Company, and managed by Wyatt W. Miller, Safe Harbor P.O. Lancaster county Pennsylvania, was built in 1848, has 33 furnaces in all, and 2 trains of rolls, driven by steam and made in 1845 10,653 tons of rails and 145 of rounds, out of pig iron and some scrap. A foundry is attached.

98. Colemanville Rolling Mill, twelve miles southwest of Lancaster, owned by George Dawson Coleman of Lebanon, and managed by Maris Hoopes, Colemansville P.O. Lancaster county Pennsylvania, was built in 1828, has 4 heating furnaces and 2 trains of rolls, driven by water, and makes about 1,600 tons a year of plate and bar iron out of pig metal.

99. Heshbon Rolling Mill, situated on the Lycoming creek five miles north of Williamsport, William McKinney late owner and manager, Williamsport P.O. Lycoming county Pennsylvania, was built in 1842, has 2 puddling and 1 heating furnace and 1 train of rolls, driven by water power, and has made about 300 tons of bars and rods per annum out of blooms.

100. Crescent Rolling Mill, situated on the Lycoming creek, eleven miles north of Williamsport, is owned and managed by H. D. Heelman & Company, Crescent P.O. Lycoming county Pennsylvania, was built in 1842, has 2 puddling and 1

heating furnace, 1 train of rolls, 1 spike and 6 nail machines, and has made about 400 tons of bars and nails per annum out of pig and scrap.

101. Blossburg Rolling Mill, situated on the Tioga river and railroad, forty miles south of Corning, Steuben county New York, is owned and managed by J. H. Gulick, Blossburg P.O. Tioga county Pennsylvania, was built in 1850, has 1 puddling and 1 heating furnace and 1 train of rolls, driven by steam, and made in 1856 322 tons of bar iron out of pig and scrap.

102. Howard Rolling Mill and Forge, F. 170, on Lick run, in the gap of Bald Eagle mountain, twelve miles northeast of Bellefonte, is owned and managed by John Irwin junior & Company, Howard P.O. Centre county Pennsylvania, was built in 1840, has one train of rolls, driven by water, and made in 1856 891 tons of merchant bar iron of all kinds.

103. Hecla Rolling Mill, situated three-quarters of a mile from the Bellefonte and Lockhaven railroad, three hundred yards northeast from the furnace, 115, Table E. seven miles east-southeast of Bellefonte, is owned and managed by Gregg, Irvin & Company, Hublersburg P.O. Centre county Pennsylvania, was built in 1846, has 3 trains of rolls, driven by steam, and made in 1856 283 tons of plate out of Hecla furnace pig.

104. Milesburg Rolling Mill, on the Bald Eagle canal, half a mile south of Milesburg, and one and a half below Bellefonte, is owned and managed by Irvin, McCoy & Company, Milesburg P.O. Centre county Pennsylvania, is 30 years old as a boiler plate mill, but was built in 1831 as a bar mill, and again rebuilt in 1849; has 2 heating furnaces, 2 trains of rolls and 5 nail machines, is driven by water, and has made about 1,000 tons per annum of finished merchant bars, slit rods and a few nails out of rough bars from the forge F. 172, which contains the puddle rolls.

105. Eagle Rolling Mill, four and a half miles northeast of Bellefonte, is owned and managed by C. & J. Curtin, Milesburg P.O. Centre county Pennsylvania, was built in 1831, has 1 puddling and 1 heating furnace, 2 trains and 2 nail machines, driven by water, and made in 1857 851 tons of merchant bar

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for shovels and scythes, and some slit rods out of Eagle furnace pig E. 116, and Eagle forge blooms F. 171.

106. Bellefonte Rolling Mill, one mile southeast of Bellefonte in Centre county Pennsylvania, and leased by Valentines, Thomas & Company, was built in 1825, uses one of its 2 puddling and 2 heating furnaces, has 2 pairs of rolls and 2 nail machines, is driven by water, and made in 1854 1,179 tons of slit rods, wire, billets, shovel and scythe iron out of pig, chiefly blooms and a little scrap.

107. Portage Rolling Mill, on the Alleghany Portage railroad, two miles west of Hollidaysburg. H. N. Burroughs, J. Higgens & Royer & Schmucker owners, Burroughs & Higgens lessees, Jos. Higgens manager, Duncansville, Blair county Pennsylvania, was built in 1839, and its nail factory rebuilt in 1854, has 10 furnaces in all, 3 trains of rolls and 8 nail machines, driven by steam, and made in 1856 1,228 tons of assorted bars and 9,270 kegs of nails out of principally pig metal with some little bloom and scrap.

108. Juniata Rolling Mill, No 1, on the Juniata river, one mile east of Alexandria in Huntingdon county Pennsylvania, owned and managed by S. Hatfield junior, was built in 1838, has 2 puddling and 2 heating furnaces and 2 trains of rolls, driven by water, and made in 1857 432 tons of bar and sheet iron out of pig.

109. Juniata Rolling Mill, No. 2, on Shaver's creek in Huntingdon county Pennsylvania, owned by the heirs of E. N. Shoenberger, was built in 1847, abandoned and its machinery removed since 1849, when it made 100 tons of manufactured bar.

110. Mont Alto Rolling Mill, one mile south of the forges 140, 141, Table F. on the same stream with all the other works, Antietam creek, and nine miles southeast of Chambersburg, is owned and managed by Holker Hughes, Mont Alto P.O. Franklin county Pennsylvania, was built in 1832, has 2 hammers, 2 heating furnaces and 2 trains of rolls, is driven by water power, and makes in half of every year about 500 tons of bars and horseshoe nail rods out of blooms and scrap. The nail factory was burnt down some years ago and never rebuilt.

111. Wilmington Rolling Mill, situated nearly a mile east of the railway station in Wilmington, owned and managed by

Gibbons & Hilles, Wilmington P.O. Newcastle county Delaware, was built in 1845 and enlarged in 1850, uses one of its 2 heating furnaces, 1 train of rolls and a Nasmyth hammer, driven by steam, and made in 1856 653 tons of plate iron out of blooms and some little scrap.

112. Diamond State Rolling Mill, a quarter of a mile east of the railway station in Wilmington, Newcastle county Delaware, owned and managed by McDaniel, Craige & Company, was built in 1854 and enlarged in 1857, has 4 furnaces in all and 2 trains of rolls, driven by steam, and made in 1856 838 tons of small bar, band, scroll, oval, rivet and horseshoe iron from scrap and blooms.

113. Delaware Iron Works, five miles northwest of Wilmington in Newcastle county Delaware, half a mile off the Lancaster turnpike, owned by Alan Wood of Philadelphia (office No. 38 North Front street), built in 1812, began to manufacture sheet iron about 30 years ago in what had been a nailplate works. At that time only Townsend in New Jersey made sheet iron. It has 1 puddling and 2 heating furnaces and 1 train of rolls, driven by water, and made in 1856 327 tons of artificial Russia sheet iron, the manufacture of which was discovered here.

114. Marshall's Rolling Mill, on Red Clay creek, two miles west of Newport, and four and a half miles northwest of Wilmington, owned and managed by C. & J. Marshall, Newport P.O. Newcastle county Delaware, was built in 1836, has 2 puddling, 2 heating furnaces and 1 train of rolls, driven by water, and made in 1856 393 tons of sheet iron from charcoal blooms.

115. Elk Rolling Mill, on the Big Elk river, five miles north of Elkton in Cecil county Maryland, where a rolling mill (probably copper works), existed in the time of the Revolution, was built about 1810 and assumed its present form about 1825 or 1830, is owned and managed by Parke, Smith & Company, Elkton P.O., has 1 puddling and 2 heating furnaces and 1 train of rolls, driven by water, and made in 1855 about 450 tons of sheet iron out of pig metal and some blooms.

116. West Amwell Iron Works, on Big Elk creek, two miles north of Elkton in Cecil county Maryland, is owned by

E. A. Harvey of Wilmington, Delaware, and managed by George Harlan, was built in 1854 and enlarged in 1857, has 1 puddling, 4 heating furnaces and 1 train of rolls, driven by water, and made in 1856 337 tons of sheet iron.

117. Northeast Rolling Mill, on the Wilmington and Baltimore railroad, one hundred yards east of the station on Northeast creek, owned by McCullough & Company of Wilmington, and managed by Mr. Scott, Northeast P.O. Cecil county Maryland, was built, burnt down and rebuilt in 1847, has 1 puddling, 1 heating furnace and 1 train of rolls, driven by water, and made in 1856 339 tons of sheet iron out of charcoal blooms and pig.

118. Shannon Rolling Mill, half a mile west of the Baltimore railroad station, and in sight of the railroad on Northeast creek in Cecil county Maryland, was built by McCullough & Company of Wilmington (No. 14 North Tenth street Philadelphia), in 1857, and managed, like the last, by Mr. Scott, has 1 heating furnace and 1 train of rolls, driven by water power, and makes sheet iron out of charcoal blooms.

119. Octarara Rolling Mill, at Rowlandsville (formerly Romansville), at the mouth of Octarara creek, five miles north of Point Deposit, is owned by the same parties with the last two, McCullough & Company, Jethro J. McCullough manager, Rowlandsville P.O. Cecil county Maryland, is at least twenty-five years old; has 1 puddling, 1 heating furnace and 1 train of rolls, driven by water power, and made in 1856 262 tons of sheet iron.

120. Joppa Nail Works, on Great Gunpowder Falls at head of tide fifteen miles from Baltimore, and six northwest of the Baltimore railway Magnolia station, is owned by Edward Patterson & Sons of Baltimore, and managed by S. S. Patterson Little Gunpowder P.O. Baltimore county Maryland, built in 1820 and rebuilt in 1851, has 6 puddling and 1 heating furnace, 2 trains of rolls, 37 nail machines and 1 hammer, driven by water, and made 34,000 kegs of nails.

121. Baltimore Spike Mill, on the south side of Baltimore Harbor, Baltimore county Maryland, a quarter of a mile south of the Maryland Furnace, owned by J. Hopkinson Smith, has 4

heating furnaces and 7 spike machines, and makes railroad chairs out of plate iron, and spikes out of bar.

122. **Canton Rolling Mill,** No. 1, situated about a quarter mile above Cedar Point Furnace, and two miles from the centre of the city, on the Canton suburb of Baltimore, Baltimore county Maryland, and owned and managed by H. Abbott & Son, was built in 1851 and enlarged in 1854, has 10 furnaces in all, 3 trains of rolls and 1 hammer, driven by steam, and made in 1856 perhaps 2,000 tons of plate out of pig iron and some blooms.

123. **Canton Rolling Mill,** No. 2, was added in 1857, with 6 furnaces in all, 2 trains of rolls and a Nasmyth hammer, is driven by steam, and makes plate like No. 1.

124. **Baltimore Steam Forge and Bar Iron Rolling Mill** (see Table F. No. 124), situated near the Philadelphia railroad station in East Baltimore, Maryland, and owned by Fagely, Heird & Company, was built in 1856, has 9 furnaces in all, 2 trains of rolls, 1 three-ton Nasmyth and 1 kirk hammer, driven by steam, goes night and day, employs one hundred hands and makes refined and hammered iron, for machine, bridge and railway purposes.

125. **Avalon Iron Works,** on the Baltimore and Ohio railroad, half a mile above the Relay House in Baltimore county Maryland, owned by Joseph C. Manning & Company of Baltimore, and managed by Elijah Spurrier, is one of the oldest in the State, built by the Dorseys some say sixty years ago, was pulled down and rebuilt in 1854. The old nail factory was burnt down about 1845 and rebuilt in 1850. The puddling mill was built in 1853. It has 7 puddling and 3 heating furnaces, 3 trains of rolls and 44 nail machines, is driven by steam and made in 1856 about 40,000 kegs of nails. Before 1850 it rolled rails.

126. **Antietam Rolling Mill,** seven miles above Harper's Ferry, owned and leased by Horine, Yeakle & Company, and managed by J. Hewitt, Sharpsburg P.O. Washington county Maryland, was built about 1831, separated from the forge (F. 146) about 1845, and has not been used since 1853. It has 2 heating furnaces, 2 trains of rolls and 25 nail machines, driven by water.

127. Mount Savage Rolling Mill, situated in the Frostburg coal basin, eight miles west of Cumberland and close to the Mount Savage Blast Furnaces H. 286, 287, 288, owned by the Mount Savage Iron Company, Samuel Danks superintendent, Cumberland P.O. Alleghany county Maryland, was built in 1839, has 27 furnaces in all and 2 trains of rolls, driven by steam, and made in 1855 8,350 tons of rails, out of equal quantities of pig iron and old rails.

128. Tredegar Rolling Mill, near the James river bank in Richmond, Henrico county Virginia, owned by Morriss, Tanner & Company, and managed by John Hartman, has 9 puddling, 7 heating furnaces, 3 trains of rolls, 2 rail spike and 1 rail chair machine, driven by water power, and made in 1856 perhaps 3,500 tons of bar iron, spikes and chairs.

129. Armory Rolling Mill, between the Tredegar works last described and the river, in Richmond, Henrico county Virginia, owned by R. Archer & Company, and managed by Edward Wade, has 8 puddling, 3 heating furnaces and 2 trains of rolls, driven by water power, and made in 1856 perhaps 2,000 tons of bars and chairs.

130. Richmond Steel and Iron Works, situated on the river bank under the railroad bridge at Richmond, Henrico county Virginia, owned by James Hunter & Company, and leased and managed by James Hunter, has 1 heating furnace and 1 train of rolls, driven by water power, and made in 1856 about 400 tons of merchant bar iron out of scrap and old rails. Has made no spikes for three years.

131. Old Dominion Nail Works, at Richmond, Henrico county Virginia, H. W. Fry manufacturer, W. S. Triplett agent, D. Baird manager, has 7 puddling and 2 heating furnaces, 1 train of rolls, 48 nail machines and 1 hammer, driven by water, and made in 1856 about 1,074 tons of nails, out of pig iron.

132. Graham's Rolling Mill, on Reed creek, six miles southeast of Mac's Meadows, Virginia and Tennessee railway station and twelve miles east of Wytheville, under the same roof with Graham's Forge, I. 233, is owned like that by David Graham and managed by Mitchel B. Tate, Graham's Forge P.O. Wythe county Virginia; was built in 1826 and again in 1856;

has 1 heating furnace, 1 train of rolls and 5 nail machines, driven by water power, and made in twenty-one weeks of 1856 161 tons of merchant bars, plate iron and nails.

133. Brigg's Iron Works, situated on Crowder's creek ten miles south from Dallas, and one and a quarter miles north of Kings Mountain, Gaston county North Carolina, owned and managed by Benjamin F. Briggs, Yorkville P.O. in South Carolina, was built in 1853, has 1 heating furnace and 2 trains of rolls and works up the forge blooms into round and square bar iron for home market, making about 215 tons a year.

134. Highshoals Works, situated on South Catawba river, six miles south from Lincolnton, seven north from Dallas, and seven east from Columbia Furnace. Has been in ruins since January 1, 1854. The works belong to the Highshoals Mining and Manufacturing Company, office No 4 Bowling Green, New York city, T. Darling agent, Nail Factory P.O. Gaston county North Carolina.

135. Hurricane Rolling Mill and Nail Works, situated on Pacolet river, seven miles east-northeast of Spartanburg in Spartanburg District of South Carolina, owned by the South Carolina Manufacturing Company, Simpson Bobo agent, and built in 1834, has 5 furnaces in all, 1 train of rolls, 3 nail machines and 1 hammer, driven by water power, and has made about 390 tons of merchant bar iron and nails per annum, out of pig metal.

136. Cherokee Ford Works, situated on Broad river, twenty-six miles northeast of Spartanburg and twenty-four miles north-northwest of Yorkville, owned by the Swedish Iron Manufacturing Company, and managed by A. M. Latham, Coopersville P.O. Union District in South Carolina, was built in 1840 and is about abandoned; has 1 puddling and 2 heating furnaces, 2 trains of rolls, 5 nail machines and 1 hammer, driven by water power, and made in 1856 400 tons of merchant bar iron and nails out of charcoal blooms.

137. Cherokee Iron Works, situated on the west bank of the Broad river, and south bank of London Bridge creek, one and a half miles below the forges, and two and a half miles below the Swedish Iron Works, is owned by the Kings Mountain Iron Company, and managed by M. M. Montgomery Cherokee Iron Works P.O. York District South Carolina, was built about 1825, has 1 refining and 1 heating furnace and 4 pairs of rolls,

driven by water power, and made in thirty-three weeks of 1856 420 tons of merchant bar iron out of charcoal pig.

138. Etowah Rolling Mill, situated on Etowah river, one and a half miles north of the Allatoona Furnace, four miles northeast of Allatoona, Cass county Georgia, owned by the Etowah Manufacturing Company, M. A. Cooper president, E. A. Hicks treasurer, and J. W. Churchill superintendent, was built about 1849, has 9 furnaces in all, 3 trains, 3 nail machines and 1 hammer, driven by water, and made in 1856 perhaps 900 tons of merchant bar out of charcoal pig iron.

139. Gate City Rolling Mill, in the town of Atlanta, on the Georgia railroad half a mile from the Atlanta railway station, owned and managed by L. A. Douglas, Atlanta P.O. Fulton county Georgia, was built in 1858, has 6 puddling 8 heating furnaces and 2 trains of rolls, driven by steam, and has a capacity to make 12,000 tons of railroad iron out of old rails and pig metal for the southern railroads.

140. Pleasant Valley Rolling Mill, situated at Emeryville, on Nolichucky river, one hundred and fifty yards below the furnace, H. 269, eight miles southeast of Washington College, and eight miles south of Jonesborough, owned by John Blair & Company, Cox's Store P.O. Washington county Tennessee, and managed by the same, was converted from the old bloomary forge (1790) to a rolling mill about in 1833, has 5 refinery fires, 2 heating furnaces, 2 pairs of rolls and 5 nail machines, driven by a fine water power, and made in 1856 perhaps 150 tons of bars and nails.

141. Loudon Rolling Mill, on the Tennessee river at Loudon, thirty miles southwest of Knoxville by railroad, and a hundred yards from the railroad station, owned by Samuel M. Johnson & Company, and leased by Jones, Philips & Company, Loudon P.O. Roane county Tennessee, was built in 1854 and enlarged in 1857, has 2 boiling and 1 heating furnace, and 2 trains of rolls, driven by steam, and made in a quarter of 1854 perhaps 100 tons of bar and rod iron, and nothing since.

142. Reeve's Rolling Mill, on the Watauga river, at the crossing of the road to Jonesborough, one mile from Elizabethton in Carter county Tennessee, and owned by J. I. Tipton, was built 1829–30, or earlier, and abandoned in the spring of 1852, had a nail factory, forge and cupola furnace, all now in ruins.

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143. **Gillespie's Rolling Mill,** cn Watauga river, three miles from the railroad, and four miles below Elizabethton, in Carter county Tennessee, was begun in 1849 and never finished, or at least never run. It had 6 nail cutters.

144. Cumberland Iron Works, see No. 207. **Table J**

145. Cambria Iron Works, at Johnstown, Cambria county Pennsylvania, seventy-six miles east of Pittsburg, on the river Conemaugh, between the Pennsylvania Central railway station and the furnaces H. 347, etc., owned by the Cambria Iron Company and leased by Wood, Morrell & Company of Philadelphia, was built in 1854, burnt and rebuilt in 1857, in the form of a cross 612 feet long one way by 372 the other, has 30 puddling and 12 heating furnaces, and 4 trains of rolls, driven by steam, and made in 1857 17,808 tons of rails out of coke and charcoal pig.

146. Fairchance Rolling Mill, in Uniontown in Fayette county Pennsylvania, at the western base of West Laurel Hill or Chestnut Ridge, on the waters of George's creek, near the National road, owned by F. H. Oliphant and managed by G. W. Paull, was built in 1834, has 2 puddling, 2 heating furnaces, 3 trains of rolls and 3 nail machines, driven by steam, and made in 1856 perhaps 600 tons of bar iron and nails.

147. Brownsville Rolling Mill, situated on the Monongahela river at Brownsville, Fayette county Pennsylvania, thirty-five miles above Pittsburg, owned last by R. Rodgers, and sold, dismantled and abandoned in 1853, had 8 fires in all, 3 trains and 10 machines, driven by steam, and made in 1849 600 tons of bars and nails.

148. McKeesport Rolling Mill, situated on the south side of the Monongahela, at McKeesport in Alleghany county Pennsylvania, fifteen miles above Pittsburg, owned by Wood, Morehead & Company, office 134 First street Pittsburg, was built in 1851, uses 6 heating furnaces and 4 trains of rolls driven by steam, and made in 1857 477 tons of bar iron, imitation Russia and galvanized and corrugated sheet.

149. American Rolling Mill, situated on the south bank of the Monongahela, two miles above the bridge, and half a mile above Birmingham ferry wharf, owned by Jones, Lauth & Company, 98 Water street Pittsburg, Alleghany county Pennsyl-

Table J

vania, was built in 1853, with 31 furnaces in all, 5 trains of rolls and 25 nail machines, driven by steam, and made in 1857 about 6,000 tons of merchant bar iron and nails, out of pig iron and a little scrap.

150. Western Tack Factory, situated in Birmingham on the south bank of the Monongahela, half a mile below the American rolling mill and half a mile above Birmingham ferry, is the only tack factory in the west, and none east of it nearer than Rhode Island, and one in the upper part of the State of New York. It is owned by Chess, Wilson & Company and managed by David Chess, 119 Water street Pittsburg, Alleghany county Pennsylvania, was added in 1854 to an older mill built about 1845, has 9 furnaces in all, two trains of rolls and 80 nail and tack machines, driven by steam, and made in 1857 about 1,400 tons of nails and tacks of over three hundred sorts.

151. Hecla (formerly Birmingham) Rolling Mill, situated in Birmingham, on the south side of the Monongahela, a furlong above the Birmingham ferry, owned by J. & W. McKnight, Mr. McCutcheon clerk, 111 Water street Pittsburg, Alleghany county Pennsylvania, was built in 1841, has 13 puddling and 6 heating furnaces, 3 trains and 20 nail machines, driven by steam, and made in 1856 about 4,000 tons of bars, rods and nails, out of pig metal.

152. A New Mill, situated in Birmingham, on the south side of the Monongahela, just below the Birmingham ferry, owned and managed by Porter, Rolph & Swett, office in Pittsburg, Alleghany county Pennsylvania, was built in 1857, with 3 puddling and 2 heating furnaces and 2 trains of rolls, driven by steam, and makes bars for the spike factory situated near the Duquesne rolling mill 165, in Pittsburg.

153. Sligo Rolling Mill, situated on the south side of the Monongahela, just below the bridge, Pittsburg, owned by Lyon, Shorb & Company, and managed by F. Wernet, office 121 First street Pittsburg, Alleghany county Pennsylvania, built in 1825, has 24 furnaces in all, and 5 trains of rolls, driven by steam, and made in 1857 5,454 tons of bar, plate and sheet iron, out of Juniata river and Clarion county charcoal iron.

154. Clinton Rolling Mill, situated on the south side of

the Monongahela, a furlong below the bridge, owned by Graff, Burnet & Company, 97 Water street Pittsburg, Alleghany county Pennsylvania, and managed by Mr. Marshall, was built in 1845, has 28 furnaces in all, 5 trains and 21 nail machines, driven by steam, and made in 1857 perhaps 5,000 tons of bars and plates and nails, out of mixed coke and charcoal pig iron.

155. Pittsburg Rolling Mill, situated in South Pittsburg, on the south side of the Monongahela, a quarter mile below the bridge, owned by Zug & Painter, 96 Water street Pittsburg, Alleghany county Pennsylvania, was built in 1837, has 30 furnaces in all, and 6 trains of rolls, driven by steam, and made in 1856 7,085 tons of bar, rod and sheet iron, out of pig iron with Lake Superior ore and some Juniata blooms. The nails are made at the Sable Iron Works in Pittsburg.

156. Sheffield Rolling Mill (or Forge), situated in South Pittsburg, on the south side of the Monongahela, three-quarters of a mile below the bridge, owned by Singer, Hartman & Company, 82 Water street Pittsburg, Alleghany county Pennsylvania, was built in 1848, has 4 puddling, 9 heating and 5 converting furnaces, 3 trains of rolls, 6 forge fires and 2 hammers, driven by steam, and made in 1856 perhaps 3,600 tons of vices, axles, spring steel and puddled iron.

157. Eagle Rolling Mills, in the borough of West Pittsburg, on the left bank of the Ohio river, at the mouth of Sawmill Run, one mile below the Monongahela bridge, owned by James Wood, Robert B. Sterling, James O. H. Sealley, James I. Wood and Charles A. Wood, 113 Water street Pittsburg, Alleghany county Pennsylvania, and managed by G. Wittengill, was built in 1850, has 31 furnaces in all, 7 trains of rolls and 38 nail and spike machines, driven by steam, and made in 1856 about 8,000 tons of nails and spikes, bar and steel iron and plough steel, out of charcoal pig and some blooms and 1,000 tons of scrap.

158. Pennsylvania Forge Rolling Mill, situated on the north side of the Monongahela, a mile above the bridge, owned by Everson, Preston & Company, 94 Water street Pittsburg, Alleghany county Pennsylvania, was built in 1844, has about 20 furnaces in all, 2 trains of rolls and 2 hammers, one a Nas-

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myth, driven by steam, and made in 1856 perhaps 3,000 tons of merchant bar and forge shapes.

159. Kensington Rolling Mill, situated on the north side of the Monongahela, at Pipetown, a quarter mile below the last, between the street and the river, and half a mile above the bridge, is owned by Miller, Lloyd & Black, 99 Water street, Pittsburg, Alleghany county Pennsylvania, and managed by Mr. Nickson, was built in 1845, has 12 puddling and 5 heating furnaces, 3 trains of rolls and 13 nail machines, driven by steam, and made in 1856 about 4,300 tons of bar and sheet iron and nails.

160. Pittsburg Steel Works, in Pittsburg, three squares above the Monongahela bridge, is owned and managed by Isaac Jones, corner of Ross and Front streets Pittsburg, Alleghany county Pennsylvania, was built in 1835, has 4 converting furnaces, and makes perhaps 1,000 tons of steel.

161. Wayne Rolling Mill, situated at the foot of Wayne street on the Alleghany river, built in 1829 by Mr. Oliphant, enlarged in 1835 by the present owners Bailey, Brown & Company, 120 Water street Pittsburg, Alleghany county Pennsylvania, and managed by J. D. Bailey, has 21 furnaces in all, 3 trains of rolls and 37 nail machines, driven by steam, and made in 1856 about 5,500 tons of bars and nails out of pig iron, with scrap and blooms.

162. Sable (old Lippincott) Rolling Mill, situated at the foot of Walnut street on the east bank of the Alleghany river, owned by Zug & Painter, 96 Water street Pittsburg, Alleghany county Pennsylvania, was established originally as a shovel factory by Zeb. Packard in 1828, became a rolling mill in 1830 and was enlarged in 1852, has 28 furnaces in all, 3 trains of rolls and 36 nail machines, driven by steam, and made in 1856 about 3,500 tons of bar and hoop iron and nails.

163. Juniata Rolling Mill, No. 1, in Alleghany city opposite to Pittsburg, owned by Semple, Bissell & Company, was built in 1828 and abandoned in 1849, disappeared and its site is occupied by a vice factory.

164. Juniata Rolling Mill, No. 2, situated between Mechanic, Pike, Adams streets and the Alleghany river in Pittsburg, Alleghany county Pennsylvania, was established by Dr.

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P. Shoenberger in 1826, and is managed by Mr. Crawford & Brother in the mill, and Mr. Myers in the factory, office of the company 93 Water street. It has 32 furnaces in all, 7 trains of rolls and 49 nail machines, driven by steam, and made in 1855 9,663 tons of bar and sheet iron, nails, cast-steel, etc.

165. Duquesne Rolling Mill, in Pittsburg, 312 feet on the Alleghany east bank and on Etna street, and 400 feet deep, was established in 1846 by the present owners Coleman, Heilman & Company, 121 Water street Pittsburg, Alleghany county Pennsylvania, William Varnum manager, has 30 furnaces in all, 5 trains of rolls, 30 nail machines and 3 hammers, driven by steam, and made in 1856 about 6,800 tons of bar iron, steel and nails out of all kinds of pig metal, lake ore and much scrap.

166. Lorenz Rolling Mill, situated on the west side of the Alleghany, opposite the Lawrenceville arsenal and ferry, three miles above Pittsburg, owned by Lorenz, Stewart & Company, 62 Water street Pittsburg, Alleghany county Pennsylvania, was built in 1856, with 20 furnaces in all, 6 trains of rolls and 21 nail machines, driven by steam, and makes about 5,000 tons of bar iron and nails per annum, principally out of Anthracite, with some Hanging-rock pig metal, lake ore and scrap.

167. Etna Rolling Mill, situated on Pine creek, one mile from its mouth on the west side of the Alleghany river, four miles above Pittsburg, Alleghany county Pennsylvania, owned by Spang & Company 91 Water street, and managed by A. G. Lloyd, was built in 1828, has 25 furnaces in all, 4 trains of rolls and 24 nail machines, driven by steam, and made in 1855 about 5,000 tons of bar and sheet iron and nails out of nearly all charcoal cold blast pig metal, with some anthracite, Juniata blooms and scrap.

168. Vesuvius Rolling Mill, situated on the canal, west side of the Alleghany river, a furlong above the end of the Sharpsburg bridge, five miles above Pittsburg, owned by Lewis, Dalzell & Company, 110 Water street Pittsburg, Alleghany county Pennsylvania, was built in 1845, has 25 furnaces in all, 4 trains of rolls and 37 nail machines and made in 1856 about 6,000 tons of bar and sheet iron and nails.

169. Kittanning Rolling Mill and Foundry, situated on the bank of the Alleghany river between it and the Alleghany Valley railroad, ten perches from each, forty-two miles above Pittsburg, owned by Colwell, Brown & J. & R. Floyd, Kittanning P.O. Armstrong county Pennsylvania, was built in 1848, has 20 furnaces in all, 3 trains and seven machines, driven by water, and made in 1857 2,550 tons of bar iron, nails and castings.

170. Brady's Bend Rolling Mill, situated at Brady's Bend, seventy-one miles by water and sixty miles by land above Pittsburg, owned by the Brady's Bend Iron Company, Brady's Bend P.O. Armstrong county Pennsylvania, H. A. S. D. Dudley superintendent, was built in 1841, has 35 furnaces in all and 5 trains of rolls, and made in 1856 7,533 tons of railroad iron.

171. **Franklin Rolling Mill,** near the mouth of French creek, sixty-nine miles north of Pittsburg, sixty miles south of Erie, near Susquehanna and Waterford turnpike in Venango county Pennsylvania, built in 1844, had 2 furnaces and 10 nail machines, driven by water, but has been abandoned since about 1852.

172. Sharon Rolling Mill, on the east bank of the Chenango, one quarter mile above the Sharon bridge, owned by the Sharon iron company, S. H. Kimball of Erie Pennsylvania president, J. Barber manager at Sharon, Lawrence county Pennsylvania, has 11 puddling furnaces, 7 heating furnaces, 5 trains of rolls, 3 spike and 16 nail machines, driven by steam, and made in 1854 33,600 kegs of nails, besides a good deal of boiler iron. Ceased making iron and nails in 1855 and began with 4 converters and 20 melting furnaces and 1 train of rolls, making steel direct from Lake Superior ore by G. Hand Smith's patent.

173. Orizaba Rolling Mill, situated alongside of Sharon furnace in Newcastle, Lawrence county Pennsylvania, fifty miles northwest of Pittsburg, owned by McCormick's trustees, managed by Mr. Beshore, built in 1847, has 23 furnaces in all, 4 trains of rolls and 50 nail machines, driven by steam, and made in 1856 84,176 kegs of nails and 3,397 of spikes.

174. Cosalo Rolling Mill, situated between the Shenango and Neshannoc, on the canal at the south end of Newcastle in Lawrence county Pennsylvania, owned by the Crawford Bro-

thers, managed by H. J. Evans, was built in 1839 or 1840, has 21 furnaces in all, 4 trains of rolls and 33 nail and 2 spike machines, driven by steam and water power, and made in 1849 1,700 tons of bar iron and nails. In 1853 it made 4,000 tons of the Winslow split rail.

175. Mahoning Rolling Mill, in Youngstown, Mahoning county Ohio, sixty-five miles northwest of Pittsburg by canal, and sixty-five miles southeast of Cleveland by railroad, situated three hundred yards above Phœnix furnace H. 460, owned by Brown, Bonnell & Company, and managed by James H. Brown, has 9 puddling and 3 heating furnaces, 3 trains of rolls and 16 nail machines, driven by steam, and made in 1856 1,875 tons of bar iron, spikes and nails.

176. Falcon Rolling Mill, on the north side of Mahoning creek at the bridge in Nilestown, Trumbull county Ohio, seventy-five miles from Pittsburg, is owned by James Ward & Company, was built in 1842 and enlarged in 1853, with new machinery and a sheet mill. It has 11 puddling and 5 heating furnaces, 4 trains of rolls and 15 nail machines, driven by steam, and made in 1857 about 2,300 tons of bar and sheet iron and nails.

177. Railroad Iron Works, on the Lake Shore road, with a coal branch from the Pittsburg & Cleveland road, two miles east of Cleveland, owned by the Railroad Iron Mill Company, A. G. Smith president and manager, Cleveland P.O. Cuyahoga county Ohio, was built in 1856, has 5 puddling and 8 heating furnaces and 3 trains of rolls, driven by steam, and made in 1857 about 6,000 tons of railroad iron.

178. Newburg Rolling Mill, three hundred yards northeast of the Newburg station, Pittsburg & Cleveland railroad, six miles southeast of Cleveland, owned and managed by Chillon & Jones, Newburg P.O. Cuyahoga county Ohio, was built in 1857, with 4 heating furnaces and 3 trains of rolls, driven by steam, and makes railroad iron at a present rate of about 28 tons a day.

179. Zanesville Rolling Mill, on the bank of the Muskingum river, half a mile north of the Zanesville court-house in Muskingum county Ohio, owned by the Ohio iron company,

Campbell, Peters & Company of Ironton Ohio, Mr. Blandy president, and managed by Baird & Davis, was built in 1847, enlarged about 1850 and rearranged in 1856 for a bar, sheet, nail and axle mill, with 12 furnaces in all, 2 trains of rolls, 8 nail machines and 2 hammers, driven by steam, and makes about 200 tons of bars per month—in 1857 480 tons.

180. Columbus Iron Works, on the Scioto river, east side, between the bridge and the prison, owned by Peter Haydn Columbus P.O. Franklin county Ohio, and managed by D. Serles, was built about 1847, has 11 furnaces in all, 3 trains of rolls, 4 forge fires and a hammer, driven by steam, and made in 1857 about 1,500 tons of car, hoop, rod and wire iron principally for the shops of the penitentiary, and telegraph companies, out of Missouri blooms.

181. Jefferson Rolling Mill, situated in the lower part of Steubenville, Jefferson county Ohio, seventy-three miles below Pittsburg on the Ohio river, and owned by Frazer, Kilgore & Company, all of Steubenville, and managed by F. S. Griesemer, was built in 1852 with 17 furnaces in all, 2 trains and 40 nail machines driven by steam, and made in 1857 about 2,500 tons of nails.

182. Missouri (Old Wheeling) Rolling Mill, situated just within the northern limits of Wheeling, Ohio county Virginia, and owned by James M. Tod & Company 66 Main street, was built in 1832 and was renamed when rebuilt after the fire of 1854. It has 14 furnaces in all, 2 trains of rolls, 1 spike and 14 nail machines, driven by steam, and made in 1856 about 3,400 tons of bar and plate iron and nails. It has also 4 charcoal fires and a hammer and made 500 tons of blooms.

183. Crescent Rolling Mill, situated on the south side of Wheeling creek, and said to be the largest mill in the west, 330 × 110 feet, is owned by the Crescent Iron Company, J. W. Sill president, N. Wilkinson secretary, Wheeling P.O. Ohio county Virginia, has 27 furnaces in all, and 5 trains of rolls, driven by steam, and is capable of producing 40 tons of finished rails per day.

184. Eagle Rolling Mill and Forge, on the Ohio river at Wheeling, in Ohio county Virginia, eighty miles below Pitts-

burg, owned by E. C. Dewey and managed by John Hartman, has 10 furnaces in all and 3 trains of rolls and made in 1855 1,503 tons of merchant bar. It makes wire also, railroad axles and general forging; was stopped in 1856 and has been idle ever since.

185. Belmont Rolling Mill, situated in the 5th Ward at the south end of Wheeling, on the Ohio river and Baltimore and Ohio railroad, owned by Norton, Acheson & Company, and managed by T. D. & G. W. Norton, Wheeling Ohio county Virginia, is a broken parallelogram, 215 × 130, with an addition at the end of a nail factory 150 × 90, with 21 furnaces in all, 2 trains of rolls and 40 nail machines, driven by steam, and made in 1855 3,760 tons of cut nails.

186. La Belle Rolling Mill, situated in "Caldwell's Addition," between Wheeling and South Wheeling, Ohio county Virginia, on the Baltimore and Ohio railroad, is owned by Bailey, Woodward & Company, and managed by William Bailey, was built in 1852, has 15 puddling, 3 heating furnaces, 2 trains of rolls and 41 nail machines, driven by steam, and made in 1855 3,883 tons of nails.

187. Washington Rolling Mill, situated in South Wheeling, is a parallelogram, 185 feet on the Ohio river by about 100 deep, owned by Drakely & Fenton, Wheeling Ohio county Virginia, and managed by D. Darragh, was a small bar mill, remodelled in 1853 for a rail mill, has 14 puddling, 4 heating furnaces, and 2 trains of rolls, driven by steam, and made in 1856 2,355 tons of railroad iron out of old rails.

188. Virginia Rolling Mill, situated in the village of Benwood, on the Ohio river four miles below Wheeling, Ohio county Virginia, and owned by A. Wilson Kelly and managed by William Taylor, was built in 1852, has 15 puddling, 3 heating furnaces, 2 trains of rolls and 43 nail machines, driven by steam, and makes about 3,000 tons of rails per annum.

189. Pomeroy Rolling Mill, situated at the upper end of Pomeroy, Meigs county Ohio, on the Ohio river bank, was originally a foundry, and began to roll ten or eleven years ago, is owned by Horton, Jennings & Company, has 22 furnaces in all, 4 trains of rolls and 1 spike machine, driven by steam, and has

made about 3,000 tons per annum of bar and rod iron and railroad spikes.

190. Ironton Rolling Mill, at the lower end of Ironton, Lawrence county Ohio, on the Ohio river, one hundred and forty-four miles above Cincinnati, owned by H. Campbell & Company, managed by Mr. Beason, was built in 1852, has 12 puddling and 6 heating furnaces and 4 trains of rolls driven by steam, and makes perhaps 2,000 tons of bar, rod and sheet iron per year.

191. Star Nail Mill, on Second street, facing the old Ironton mill last described, owned by Peters, James & Company, Ironton P.O. Lawrence county Ohio, and managed by W. H. Powell and T. Pugh, was built in 1855 with 10 puddling and 3 heating furnaces, 2 trains and 38 nail machines, driven by steam, and made in 1856 1,934 tons of nails.

192. Lawrence Rolling Mill, in Ironton, Lawrence county Ohio, opposite the old rolling mill and a little above the bridge over Storm's creek, a roomy building, 90 feet wide by 200 long, owned by James Rogers & Company and managed like the last by W. H. Powell, was built in 1853 (?) with 9 puddling and 3 heating furnaces and 3 trains of rolls, driven by steam, and made in 1857 1,691 tons of merchant bar.

193. Blandy Rolling Mill, in Ironton, Lawrence county Ohio, owned by Sturgess & Blandy, was intended to occupy all the remaining space of the Ironton Flat between Storm's creek and the river bank; two rows of puddling furnaces have been erected, and the foundations of others and of a second engine stack, etc., have been laid. Large roofs cover half the ground, but the engines and roll housings have not yet been placed. Large shops stand on the north.

194. Hanging Rock Rolling Mill, at Hanging Rock in Lawrence county, the southern point of Ohio, one hundred and forty miles above Cincinnati on the Ohio river, was built as a knobbling or slabbing forge about 1827, and made into a rolling mill and was rebuilt in 1854 by S. B. Hempstead and Serman Johnson its present owners and managers, has 10 puddling and 6 heating furnaces and 6 trains of rolls, driven by steam and made in 1855 2,850 tons of merchant bar.

195. Bloom Forge Iron Works, situated in Portsmouth, Scioto county Ohio, at the corner of Front and Washington streets, owned and managed by Gaylord and Company, was renewed in 1856, has 12 puddling and 7 heating furnaces with 5 trains of rolls, and 2 hammers, driven by steam, and made in thirty-three weeks of 1856 3,565 tons of plate and bar iron.

196. Franklin Iron Works, situated at the foot of Third street, at the west end of Portsmouth, Scioto county Ohio, stand under an immense roof, 155 × 266 feet, is owned by James Murfin & Company and managed by James Evans, was established by the Scioto Rolling Mill Company in 1853, and began to run in 1855, with 10 puddling and 8 heating furnaces, 4 trains of rolls and 2 spike machines, and has made about 2,000 tons of merchant bar and spikes per annum.

197. Cincinnati Iron Works, situated on the Ohio river bank and railroad to Columbus, at the east end of the city, corner of Front and Parsons streets, one mile above the steamboat landing, is owned by Shreve, Steel & Company, was rebuilt in 1847, has 23 furnaces in all, 5 trains of rolls, driven by steam, and has made perhaps 3,000 tons of bar and sheet iron and rails per annum.

198. Globe Rolling Mill, situated at the west end of the Cincinnati levee, a mile below the Broadway, between Mill and Park streets, occupies a 200 feet square, with a smaller lathe shop and wire factory on Front street. It is owned by Worthington & company Cincinnati, Hamilton county Ohio, and managed by James Trauter, has 7 puddling and 6 heating furnaces with 3 trains of rolls, driven by steam, and made in forty-four weeks of 1857 3,554 tons of plate and bar iron.

199. McNickle Rolling Mill, situated in Covington, Kenton county Kentucky, on the bank of the Ohio river, opposite Broadway Landing, Cincinnati, and owned by J. K. McNickle's heirs, leased and managed by E. W. Stephens, was built in 1830, for a sheet and merchant mill, and remodelled in 1856 for rerolling rails, has 8 puddling and 4 heating furnaces with 2 trains of rolls, driven by steam, and made in 1857 perhaps 5,000 tons of rails.

200. Licking Rolling Mill, situated at the south end of

Covington, Kenton county Kentucky, at the foot of Eleventh street, on the west bank of the Licking river, office and depot 58 and 60 East Second street, Cincinnati, owned by Philips and Jordan, managed by Richard Jordan, built in 1848, has 15 furnaces in all and 4 trains of rolls driven by steam, and made in 1856 7,082 tons of bar, plate and sheet iron.

201. Swift's Rolling Mill (Taylor I. Works), situated on the Licking river, nearly opposite the last, and a little below, at the south end of Newport, in Campbell county Kentucky, owned by Alexander Swift and Company, and managed by Henry Westwood, was built in 1854 and finished in 1857, has 7 furnaces in all with 2 trains of rolls, and makes sheet and plate iron.

202. Newport Rolling Mill and Forge, situated at the east end of Newport, Campbell county Kentucky, on the Ohio river south bank, opposite the Cincinnati Rolling Mill 197, is owned by D. Wolff, and managed by P. Breith, has 4 puddling and 8 heating furnaces with 3 trains of rolls and 2 Nasmyth hammers, rolls sheet, boiler plate and small bars, and forges locomotive tyres.

203. Red River Rolling Mill, situated on Red river, in Estill county Kentucky, thirty-eight miles east of Lexington, owned by Josiah A. Jackson, was built in 1838 (?) and is abandoned this year owing to the cost of stone coal; it has 7 furnaces in all, 2 trains of rolls and 5 nail machines, is driven by water power and made in 1857 180 tons merchant bars.

204. Louisville Rolling Mill, on Bear Grass creek, corner of Washington and Brook streets in Louisville, Jefferson county Kentucky, owned by T. C. Coleman and Company, managed by J. Dangerfield, built in 1851, has 6 puddling and 8 heating furnaces with 3 trains of rolls driven by steam, and made in 1855 2,800 tons of bar and boiler plate.

205. Southern Iron Works, in the town of Paducah, McCracken county Kentucky, at the junction of the Tennessee and Ohio rivers, owned by Terrell, Clark & Company, leased by G. W. Hope & Company, and managed by J. H. and B. Jones, was built in 1855 with 7 puddling and 6 heating furnaces, 3 trains of rolls and 8 nail machines and made in 1857 1,576 tons of bar and sheet iron and nails.

206. Tennessee Rolling Mill, situated on the right bank of the Cumberland river, ten miles above Eddyville and two miles below Empire Furnace, in Lyon county Kentucky, opening into the forge I. 477, is owned by Hillman, Brothers, and managed by G. W. Hillman, Empire Iron Works P.O. Trigg county Kentucky, was built in 1846, has 9 heating furnaces, 4 trains of rolls and 8 nail machines not used, is driven by steam and made in 1857 3,351 tons of bar, sheet and plate iron.

207. Cumberland Rolling Mill, on left bank of Cumberland river, ten miles southeast of Dover Courthouse, and thirty miles by river below Clarksville, is owned by Woods, Lewis & Company, managed by George T. Lewis, Cumberland Iron Works P.O. Stewart county Tennessee, was built in 1829, has 2 puddling and 7 heating furnaces with 4 trains of rolls driven by steam, and made in thirty-four weeks of 1856 2,530 tons of bar, sheet and plate iron.

208. Laclede formerly **St. Louis Rolling Mill,** situated on the right bank of the Mississippi river, three miles north from the centre of the city, owned by Chouteau, Harrison & Vallé, and managed by William Mulligan, St. Louis P.O. St. Louis county Missouri, was built in 1850, burnt and rebuilt in 1856, with 15 puddling and 10 heating furnaces, and 4 trains of rolls, driven by steam, and made in 1857 2,533 tons of bar, sheet and plate iron, out of half Iron Mountain and half West Tennessee pig iron and Vallé and Maramec forge blooms.

209. Raynor's Rolling Mill, at the corner of Cass Avenue and Twelfth street in St. Louis, St. Louis county Missouri, owned by N. Raynor & Company, and managed by Moore Hardaway, was built in 1858 and contains 1 train of rolls, 1 scrap heating furnace and 1 rivet machine, to which, in the course of 1858, will be added 6 puddling and 3 heating furnaces and 1 train of rolls. The company has an establishment on Main street containing 3 spike, 2 rivet and 1 railway chair machine, 3 heating furnaces and 3 smiths' fires, all of which will be removed to the rolling mill.

210. Missouri Rolling Mill, occupies the three sides of a plot of ground fronting on Main street between Carr and Cherry streets, St. Louis, in Missouri, is owned by McFall and

Kelly, and managed by Michael Lynch, has 3 puddling and 2 heating furnaces, with 2 trains of rolls, 1 spike and 1 rivet machine, driven by steam, and made in thirty weeks of 1857 about 1,320 tons of bars, spikes and rivets. Built 1854.

211. Pacific Rolling Mill, alongside of, and in connection with the Allen Rolling Mill next to be described, is situated at the corner of Allen and Carondelet streets St. Louis in Missouri, is owned by James S. Stewart & Company, and managed by William Perry, was built in 1856, with 5 heating furnaces, 2 trains of rolls and 2 hammers, driven by steam, and made in twelve weeks of 1857 200 tons of merchant bar.

212. Allen Iron Works, in the southern part of the city of St. Louis in Missouri, at the corner of Allen and Seventh streets, is owned by Thompson, White & Prior, and managed by Michael Corcoran, was built in 1855, with 8 puddling and 4 heating furnaces, 2 trains of rolls and 43 nail machines, driven by steam, and made in 1857, perhaps 3,000 tons of nails and bar iron.

213. Maramec, or Massey's Rolling Mill, with a furnace (K. 611) and two forges, I. 492, was built in 1843, in the northwest corner of Range VI. town 37, in Crawford county Missouri, and abandoned after one year's trial.

214. Chicago Rolling Mill, on the right bank of the Chicago river, three miles above its mouth, and to the northwest and just outside the city, is just finished for the re-rolling of old rails; no new iron is to be used in this mill. It has 8 heating furnaces and 2 trains of rolls, driven by steam, and is owned by E. B. Ward of Detroit, and managed by T. C. Smith, Chicago P.O. Cook county Illinois.

215. Indianapolis Rolling Mill, situated at south end of the city of Indianapolis, Marion county, Indiana, near the Union railway station, is owned by R. A. Douglas, and managed by John Thomas, was finished in the fall of 1857, with 6 heating furnaces and 2 trains of rolls, driven by steam, under a roof 140 by 220 feet square, and can re-roll 12,000 tons of old rails per annum.

216. Wyandotte Rolling Mill, No. 1, situated on the right bank of Detroit river, in Wyandotte village, on the Detroit and Toledo railroad, ten miles south of Detroit, owned by the Wyandotte Rolling Mill Company, J. Holmes president, office at the foot of Third street in Detroit, Wayne county, Michigan, F. B.

Ward treasurer, William A. Zabriskie secretary, and Charles L. Way manager, was built in 1855, and commenced in December of same year to make merchant bars and axles, has 9 furnaces in all, and 3 trains of rolls, driven by steam, and made in 1856 1,698 tons. No. 2 was added in 1856.

217. Wyandotte Rolling Mill, No. 2, situated to the north of and opening into Mill No. 1, is a parallelogram of 140 by 180 feet, contains 8 heating furnaces and 2 trains of rolls, driven by steam, and re-rolled in 1857 8,634 tons of rails.

218. Buffalo Iron Works, is admirably situated at the north end, on a point of land between the Chicktawaga creek and Niagara river, between the New York Central railroad and the canal in the eleventh ward of Buffalo city, Erie county New York, owned by Hodgkins & Company, Joseph Corns agent, was built in 1847, 140 by 170 feet square, with 8 puddling and 3 heating furnaces, 3 trains of rolls and 24 nail machines, driven by steam, and made in 1857 about 3,000 tons of bars and nails.

219. Richardson Iron Works, situated on the south bank of Owasco outlet, under the walls of the prison in Auburn, Cayuga county New York, owned and managed by Charles Richardson, was built in 1853, with 2 double heating furnaces, 1 train of rolls and 1 large hammer, driven by steam, and made in 1857 410 tons of bars and axles out of scrap iron.

220. Jefferson Rolling Mill, situated on Black river in the village of Carthage, Jefferson county New York, owned and managed by Hiram McCollom, was built in 1847, with 1 heating furnace, 1 train of rolls, 4 nail machines and a hammer, driven by water, and has made about 200 tons of nails and horseshoe bar iron in 1857 out of blooms from the forge alongside. Attached is a machine shop.

221. Boquet Iron Works, on Boquet river, three miles due west of Essex village, Essex county New York, owned by the heirs of William D. Ross, was built in 1827, rebuilt in 1838, has 2 heating furnaces, 1 train of rolls, 26 nail machines and 1 hammer, is driven by water power, and makes about 1,400 tons of merchant bar and nails per annum.

222. Sable Iron Works, at the forks of the Au-Sable river, Essex county New York, eleven miles west of Port Kent on Lake Champlain, owned and managed by J. & J. Rogers, and built about in 1834, has 4 heating furnaces and 3 trains of rolls, and 57 nail machines, driven by steam and water, and made in 1857 3,090 tons of merchant bar and nails.

223. Peru Iron Works, situated in Clintonville on the north bank of Au-Sable river, six miles west of Keesville, eleven miles west of Port Kent, owned by Saltus & Company of New York city, and managed by William Partridge, Clintonville P.O. Clinton county New York, is driven by water power, and makes bars and nails.

224. Eagle Iron Works, in Keesville, on the north and south banks of Au-Sable river, consist of 2 rolling mills and a large machine shop, where steam engines, rolling mill machinery and heavy draught iron generally, edge tools of every description, merchant bars, horseshoes, etc., are made. The works are owned by E. & J. D. Kingsland & Company, Keesville P.O. Clinton county New York, were built in 1815, rebuilt in 1849 and damaged by the freshet of October 1856, have 6 heating furnaces, 3 trains of rolls and 40 nail machines, are driven by water, and have manufactured 4,500 tons per annum.

IRON.

PART II.

THE IRON MANUFACTURER'S GUIDE

TO THE IRON ORES OF THE UNITED STATES.

DIVISION I.

IRON AS A CHEMICAL ELEMENT.

Iron may be treated in three ways—chemically, geologically, historically; its relationship as a metal falling into three different groups. Its *chemical* combinations occupy different places in different schemes of analysis and experiments and lie at the base of all knowledge in iron manufacture. Its *mineralogical* combinations appealing to human senses as crystals of greater or less beauty and rarity or as ingredients in drugs and mineral waters or in common springs, interest and import the collector of minerals, the physician and the artisan; but they have very little value for the iron manufacturer. Its *geological* combinations, on the contrary, are his guide and stay, and will be most discussed. Over the processes ot preparing smelting and working the chemical relationships of iron are despotic, and no manufacturer of iron who is ignorant of them can command unqualified respect from his fellow craftsmen, however successful his career as an empiric may have been. It is of the essence of quackery to deal successfully by hap-hazard with the unknown; but the advancement of man in art depends upon clear science of laws leading from the known to the unknown. It is impossible to classify the geological aspects and distributions of iron without some reference to its chemistry; and impos-

sible to reason upon the former without comprehending the latter. At the same time, a guide to the useful ores of iron may safely pass by in the most cursory way numerous mineral forms of iron, the description of which very properly fills the pages of Cleveland, Phillips, Thompson, Alger, Dana and the continental mineralogists of whom Karsten is the acknowledged head so far as iron is concerned. Karsten's book has been the common treasury from which all who have written since its appearance have drawn their largest and most accurate information. It has been translated into French but never into English. In the present chapter it has been chiefly followed, and in many parts condensely translated. In mineralogy the work of Thompson holds a similar position; its order of the elements has been selected as the order to be followed in their combinations with iron.

The **place of iron in the order of the elements** varies with the quality selected to govern the order. The order in which Thompson places them relates to their mutual action on each other as active and passive, acid and alkaline.

The **acid bases** are:

Carbon,	Phosphorus,	Tellurium,	Chromium,	Columbium,
Boron,	Sulphur,	Arsenic,	Molybdenum,	Titanium,
Silicon,	Selenium,	Antimony,	Tungsten,	Vanadium.

The **alkaline bases** are:

Ammonia,	Calcium,	Zirconium,	Zinc,	Silver,
Potassium,	Magnesium,	Thorium,	Lead,	Uranium,
Sodium,	Aluminium,	IRON,	Tin,	Palladium,
Lithium,	Glucinium,	Manganese,	Bismuth,	
Barium,	Yttrium,	Nickel,	Copper,	
Strontium,	Cerium,	Cobalt,	Mercury.	

The **neutral bases** are:

Gold,	Platinum,	Iridium,	Osmium.

In this order the combinations of iron will be taken and its relationships classified not after a purely theoretical arrangement but so as to serve for a useful practical reference.

Two-thirds of the whole material universe organic and inorganic is composed of oxygen, a single one of the *sixty-three* simple elements of matter as now known. By far the greatest part of the remaining third consists of a group of so called *non-metallic* elements, headed by hydrogen, nitrogen, carbon and silicon, to which are added sulphur, phosphorus, iodine, bromine,

chlorine, fluorine, boron and selenium. The rest are called the metals, once seven in number and dedicated to the seven planets: gold to the Sun and silver to the Moon, mercury to Mercury, copper to Venus and iron to Mars, tin to Jupiter and lead to Saturn the furthest from the sun and gold.

In modern days *forty-three* new metals have been added to the list, some of which are lighter than water.[1] As has been said the place in the scale which iron takes among them must depend upon the particular quality in view when the scale is made. The following different arrangements will exhibit this; the column under A showing the order of specific gravity; B of malleability; C of ductility; and D of infusibility.[2]

Spec: gravity. A.		Malleabil: B.	Ductil: C.	Iufusibility. D.	
Platinum	20.98			Columbium	
Gold	19.26	Gold	Gold	Platinum	
Iridium	18.68			Rhodium	
Tungsten	17.50			Iridium	
Mercury	13.57			Osmium	
Palladium	11.50			Cerium	
Lead	11.35			Titanium	
Silver	10.47	Silver	Silver	Chromium	
Bismuth	9.80	Copper		Tungsten	
Uranium	9.00	Tin [3]		Uranium	
Copper	8.89	Cadmium		Molybdenum	
Cadmium	8.60	Platinum	Platinum	Palladium	
Cobalt	8.53	Lead		Nickel	
Nickel	8.27	Zinc		Manganese	
IRON	7.78	IRON	IRON	IRON	F
Molybdenum	7.40	Nickel	Copper	Cast-iron [5]	2786°
Tin	7.30		Zinc	Cobalt	
			Tin	Gold	2016°
			Lead	Copper	1996°
Zinc	7.00		Nickel [4]	Silver	1873°
Manganese	6.85			Zinc	773°
Antimony	6.70			Lead	612°
Tellurium	6.10			Tellurium	600°
Arsenic	5.80			Bismuth	497°
Titanium	5.30	Palladium	Palladium	Tin	442°
Aluminium		Potassium	Cadmium	Cadmium	442°
Sodium	0.97	Sodium		Sodium	190°
Potassium	0.86	Mercury (frozen)		Potassium	136°
				Mercury	—39°

From columbium to silver infusible below a red heat. From columbium to molybdenum fusible before the oxyhydrogen blow-pipe.

[1] Several have been lately discovered, are rare and little known.
[2] A B C, from Faraday; D, from Turner.
[3] Omitted by Régnault.
[4] Placed by Régnault between iron and copper.
[5] Daniell's scale; but 3182°—3294° F.—*Karsten* § 100.

Iron is so universally disseminated that few minerals exist without at least a trace of it in their composition; but none of these are called ores which do not contain a notable and practically useful amount. It is found in combination either with one other element, or with two, or three or more.

Iron has been reported found occasionally **native** or in a state of nature, like gold silver and copper. Iron-makers call the reduction of iron from the ore to a pure state "bringing it to nature," a traditionary expression of the past, marking all ores alloys and compounds as unnatural and secondary phenomena. Cramer, Charpentier and Klaproth mention specimens of the pure iron found in different mines, weighing several pounds. A pure, bluish-white, hackly fracture, malleable iron has been collected in small pieces from thin veins between mica slate in Canaan, Connecticut, specific gravity, 5.95 to 6.72. With it were plates of plumbago and some native steel. Klaproth's specimen contained 6 per cent lead and 1.5 copper.

Meteoric iron is iron also in a state of nature, silver white, granular, not easily rusted, specific gravity 7.3, and associated with nickel either chemically or mechanically in various proportions, one of which in Thompson's list is 35 : 3.25=10 : 1. Cobalt, tin, copper, manganese and magnetic iron pyrites often accompany meteoric metal, but not in fixed proportions.

Native Iron crystallizes in regular octahedrons, with a cleavage parallel to the faces; its streak is iron grey, its hardness 4.5; it acts strongly on the magnet. Meteoric iron has often a broad, crystalline structure, long lines and triangular figures called the Widmanstätian lines being developed upon it when polished and washed with nitric acid. The meteoric mass from Texas is remarkable for the breadth of its crystallization. The ductility of iron is such that it may be drawn into wire finer than a human hair, but it cannot be beaten into very thin leaves. It is the most tenacious of all metals, for a wire 0.787 of a line[6] in diameter is capable of supporting 550 pounds.[7] Iron is soluble in nitric acid and the solution yields a blue precipitate with prussiate of potassa, a black with infusion of galls.

[6] The twelfth of an inch.

[7] Régnault the following table of the comparative tenacity of different metallic wires 2 millimetres (.079 inch) thick, to sustain:—Iron 670 lbs.—Copper 367—Platinum 335—Silver 228—Gold 182—Zinc 134—Tin 43—Lead 34.—*Chimie* ii. 25.

Iron and Oxygen.

Iron and Oxygen form two combinations, a protoxide and a peroxide, besides which there is a mixed proto-peroxide or magnetic oxide.

Faraday gives 1,000 million lbs. of oxygen as the consumption daily of the human race in breath, and another 1,000 in combustion and fermentation, 2,000 in animal breath, while 4,000 million lbs. of oxygen are daily used to keep alive the never-ceasing functions of decay. Oxygen is the fire that burns up all things slowly. The whole world is therefore always on fire of oxygen. It pervades and works in all things, forms $\frac{3}{4}$ of every animal, $\frac{4}{5}$ of every vegetable, $\frac{1}{2}$ of the mineral kingdom, $\frac{8}{9}$ of the ocean and $\frac{1}{5}$ of the atmosphere. It is watching all things, ready to attack them; it attacks all metals impatient to reduce them to an earthy form; the moment a meteor falls to the earth, it begins to oxidize. Were a stream of molten iron to issue from a volcanic chasm it would be rusted over before it could cool. Oxygen watches iron in the custody of other elements carbon phosphorus and sulphur, and sooner or later finds a way to steal and burn it up. Man reclaims the iron and restores it to its simple freedom, beautifies ennobles and environs it with guards, but before his back is turned oxygen insinuates its fire at the weakest points, the warrior's sword falls to powder in his hand and the corselet perishes like a worm-eaten piece of wood upon his breast. As there is four times as much of this subtile element in the compound we call water than there is in the compound we call air, the fleeting and variable moisture of the air accomplishes far more of this reduction of iron to its state of rust than dry air itself can do, and therefore the surface of the metal will retain its brightness longer on the lance of an Arab than on the anchor of an Algerine. The action of the oxygen-holding atmosphere upon iron in high heat is more energetic than at the common temperature, for heat is a certain motion of the particles of iron among themselves calculated to weaken their cohesion and therefore like animosity between friends calculated in an equal degree to bring them into attachment to surrounding objects. Perfectly dry air at a low temperature has no effect upon iron. Although the oxygen of the air colors the surface of pig metal as it runs from the furnace no analysis is nice enough to detect its presence; when cold the colors vanish and a grey shell remains. From the

moment red heat sets in up to welding and melting heats, air freely admitted oxidizes the surface of iron and forms forge scale and cinder, which however consist of a mixture of various degrees of oxidation.[8]

The **protoxide** is a union of one equivalent of oxygen and one equivalent of iron, that is of 8 atoms of oxygen with 28 of iron; its equivalent is therefore 36. It never occurs in nature as an ore except in combination, and then usually with carbonic acid. In the laboratory it is made by exposing moist iron filings to the air; these do not rust red but black, and the powder thus formed is the protoxide, once a famous medicine called Mars' Black (Martial Æthiops). Iron dissolved in weak sulphuric acid, mixed with potash and dried under an air pump, rusts to protoxide in the same way. This protoxide is a black tasteless insoluble powder, subject to acids and obedient to the magnet. The salts which acids make of it let fall a white hydrate of iron when treated with potash and ammonia, a white carbonate of iron when treated with the alkaline carbonates, and Prussian blue when treated with ferrocyanide of potassium. A better way to obtain it pure is that pursued by Bucholz, passing steam over it heated to redness in a glass tube. It melts at a high temperature to a porous black glittering mass more like an enamel than a glass. Stromeyer got it pure by reducing the red oxide—not quite at a red heat—(at a red heat pure iron would be got) by hydrogen and found it a dark blue-black, reflecting almost a black, flaming easily in the open air at common temperatures returning to red oxide. Berzelius finds 100 parts of iron take up 29.47 parts oxygen, which makes the protoxide consist of 77.23 iron +22.77 oxygen.[9] It was for a long time thought that the crust which red hot iron gets in free air, called **Glühspan** by the Germans, was this protoxide, but Berthier after investigating it declared it to contain regularly 74.6 iron +25.4 oxygen, or 2 *weights* of protoxide (64.2) and 1 of peroxide (35.8). Mosander went further and showed it to consist of two distinct layers, the outside one containing more (27) and the inside one less (24.74) oxygen, and both more and more the longer the heat lasts. It is evident that the thicker the crust the more numerous will be these layers and the greater variety

[8] Karsten, §§ 136, 137.

[9] Karsten, §§ 138, 139.

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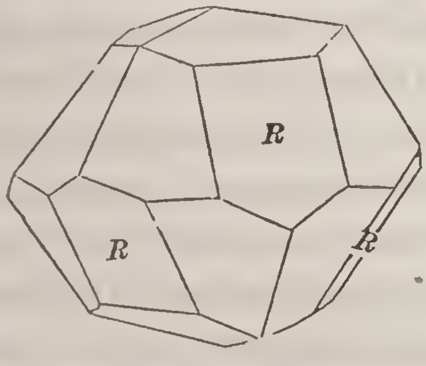
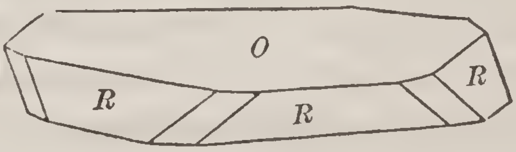
in the mixtures. The quickness or slowness of the heating and its steadiness or intermission will both affect the result. All we know is that this red-heat-crust is a peculiar oxide of iron not yet discovered in nature, and that it stands unchanged the strongest smelting heat to which pig metal is subjected, slagging to a porous enamel-like mass. But if melted in sand crucibles or in any other connection with sand it makes a very fluid more or less perfect glassy black *hammerslag* (frischschlacke, refine-slag; eisenschlacke, iron-slag), much harder to reduce to pure iron than the red-heat-crust, although so much more fusible, and making with a certain amount of silica a very fusible black glass. If the red-heat-crust be worked over long at a red heat, it falls into a dark brown, clear brown, and finally a brownish red powder, which is the perfect oxide of iron, the **peroxide**, or as it was anciently called, *astringent iron saffron*, *crocus martis adstringens.*[1]

Sandstone rocks containing protoxide of iron suffer a weathering action at their joints where peroxide of iron results, tinting the rock in concentric bands. On the other hand, marls and sandstones reddened with peroxide become green or bluish green along their joints, where vegetable reagents have robbed the peroxide of a portion of oxygen and converted it to protoxide.[2]

The **Peroxide**, or one and a half oxide (**sesquioxide**), so called because $1\frac{1}{2}$ of oxygen (=12 atoms) goes to 1 of iron (=28, making its whole equivalent 40), is the common red iron



Elba specular ore.



A crystal from a Vesuvian lava.

rust always made when iron is exposed to the air long enough to allow it to absorb as much oxygen as it will. It is, therefore, the commonest of all forms and ores of iron, and has received many names: *anhydrous peroxide* when without water; *dihy-*

[1] Karsten, §§ 139, 140, 141, 142.

[2] Delabeche, 1851; p. 15.

drous and *perhydrous* when combined with water; *red hematite*,[3] or bloodstone, when pure; *red ochre*,[4] *red chalk*, and *red lenticular clay iron-stone*, when mixed with clay; *red silicious iron-stone* when mixed with sand; *iron froth*[5] when floating on springs or dammed among mosses and ferns, or deposited from such conditions; *iron mica* when crystallized in fine plates, which are thin six-sided tables, transmitting a blood-red light; and *specular* or looking-glass *iron ore* or *iron glance* when crystallized broadly in solid masses; the French call it *fer oligiste*, and mineralogists *rhombohedral* iron ore.

When **crystallized**, the primary form is rhombic,[6] with a cleavage parallel to the primary planes and perpendicular to the axis in some varieties, an uneven conchoidal fracture, a hardness of 5.5 to 6.5 (scratched by quartz and the knife and scratching phosphate of lime) and a specific gravity of 5 to 5.25. Its lustre is steel grey often, and its surface often iridescent. It slightly obeys the magnet and its streak is red or reddish brown. This is the celebrated ore of Elba wrought by the Pelasgians before the founding of Rome, and splendid crystallizations from these mines beautify the cabinets of the world. It occurs in the Alps, in Scandinavia, in Saxony and Bohemia, Siberia and South America, in the lavas of Etna and Vesuvius, and of middle France,[7] and, in fact, in all parts of the world. The iron mountains of Missouri and Wisconsin, the plains of North Carolina, the shores of Lake Champlain and the Highlands of New Jersey and New England afford it in incalculable quantities. The micaceous or fine plate-like variety occurs at Hawley, Massachusetts; Piermont, New Hampshire; and Stafford, Vermont. When perfectly pure this mineral substance is so hard as to be used for polishing and in the place of emery.[8]

When not **crystallized**, it is a blood-red powder, pure or precipitated with clay, or sand, or shells, or vegetation. In this form we have it in the celebrated *red fossil* or *dyestone* ore of the Atlantic States, Alabama, Kentucky and Wisconsin, mixed how-

[3] Rothglaskopf in German, in masses, stalactites and kidney balls, brown-red, fibrous, radiating nearly pure peroxide, having silica 2, lime 1, water 3. [4] Reddle and Kiel.

[5] Eisenrahm in German, scaly, greasy, friable, very soft, cherry color, towards brown-red, containing (one specimen) silica (?) 4.25, alumina 1.25. [6] Sometimes it takes an octahedron, sometimes a triangular dodecahedron, truncated.—Thompson.

[7] *Volcanic glance* occurs in very flat crystals, often with curvilinear intersecting faces. —Trimmer. [8] Karsten, § 142.

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ever with its own bulk of carbonate of lime, magnesia, clay, etc. As lenticular clay stone it occurs in two beds, 12 to 20 inches thick, in a compact sandstone in Oneida, Herkimer, Madison and Wayne counties, New York, mixed with 25 per cent carbonate of lime, and more or less magnesia and clay.[9] When pure it contains 70 per cent of iron, and 30 per cent of oxygen, or more critically, F. 69.34 + O. 30.66; is infusible alone before the blow-pipe; but with borax gives a green glass in the inner flame and a yellow glass in the outer. Its red powder[1] distinguishes its crystals from magnetic iron ore, and its hardness and infusibility from any silver or copper ore. Nitric acid, when moderately strong, poured upon iron filings, instead of dissolving them, throws down a red peroxide powder; but when diluted, it dissolves them as a per-nitrate; from which solution the alkalies precipitate the same peroxide.[2] It remains unchanged at a red heat, but easily unites with silica to make slag and glass of a *yellow* color; *whereas, the protoxide glasses are green, brown and black.* Smelted with a carbonate alkali, carbonic acid is given off and a very unstable yellowish mixture remains, which falls to pure peroxide again when water is poured upon it. Boiled in water with powdered pure iron, hydrogen is given off and magnetic proto-peroxide remains (to be discussed next,) for all oxides of iron *below* the peroxide are magnetic.

Magnus first showed how the peroxide, when heated in glass tubes above boiling quicksilver (400° C. = 752° F.) and hydrogen is passed over it, yields pure iron, which when cooled and admitted to the free air at common temperature takes fire; but if it has previously been immersed in carbonic acid gas it will not—at least until it has again been exposed to hydrogen; neither will it if the original heat has been a red heat; unless, again it was originally mixed with 5 to 12 per cent of alumina; the alumina playing a merely mechanical part in the process.[3]

When **in composition with water,** the red hematite or peroxide just described makes a *hydrous peroxide, brown fibrous hematite* iron ore, *brown* and *yellow ochre, umber, brown* and *yellow clay iron stone, bog ore* of every variety of impurity with

[9] Dana.

[1] Whence its name, from αἷμα, haima, blood.

[2] Thompson; Dana; *Penny Cyc.*

[3] Karsten, § 143.

sand, mud, copperas, phosphorus, zinc, manganese and other minerals. Other forms of it have received the names *stilpnosiderite*, *bonerz*, *gothite*, *lepidokrokite*, *pyrosiderite*, *rubin-glimmer*. When the composition happens to be simple, the proportion of water[4] to peroxide is 14.7: 85.3 and (as the peroxide is $\frac{7}{10}$ iron) contains $\frac{2}{3}$ or 66 per cent of pure iron.[5]

Perfectly pure boiled water does not **rust** raw iron until it is heated to redness, when it instantly forms the red-heat-crust already described; or unless the iron be left for a long time in water, when a yellow envelope of hydrated-peroxide is the result. It even appears that pure water charged with pure air cannot rust iron; that, in fact, the free entrance of the atmosphere is needful for rusting iron in water; that the cause of the rusting according to Marshall Hall's experiments is the presence of carbonic acid in the air, for water charged with this gas oxidizes iron with rapidity and the visible evolution of hydrogen. The exact temperature at which iron decomposes water or steam is not precisely known, but it seems to be as low as a brown-red heat, a fact of importance to engine builders and engineers. Gay-Lussac affirms that water cannot oxidize iron higher than 37.8 parts of oxygen to 100 iron, answering very nearly to the proto-peroxide proportion. With this Régnault agrees. *Lemery's iron-black*, *æthiops martialis humide* (or *frigide*) *factus*, and *æthiops martialis calide factus*, is a powdered irregular proto-peroxide obtained by water for apothecary use.[6] Westrumb contended against Landriani and Girtanner that water cannot dissolve iron or its oxides. Water oxidizes iron more readily when it receives small quantities of a sulphuric, muriatic or nitric salt. On the other hand, an alkali or caustic lime destroys the oxidizing faculty of water. Some explain this fact by supposing the base to absorb the carbonic acid of the air in the water; others by supposing an electrical relationship, which is supported by the previously-men-

[4] When only half so much of water is present as in brown hematite, or when the proportions are as 10.8: 89.2, the crystals thus rarely formed are called *Goethite*, *Lepidokrokite*, *Turgite* or *Pyrosiderite* (fiery iron ore, from their brilliant color in a strong light).—Dana, and *Penny Cyc.*

[5] D'Aubuisson gives Perox. Fe. 82, water 14, ox. mang. 2, silica 1 (*Penny Cyc.*); Thompson gives a meanof Perox. Fe. 80.5, water 15.0, sesquiox. mang. 1.3, silica 2.0, or 1 atom of peroxide of iron and 1 atom of water.

[6] Karsten, § 144.

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tioned increase of the faculty by salts which are not decomposed in the oxidation. Payen made extensive experiments to determine the limit of this veto power which alkalis possess over the oxidation of iron in water, and found that a saturated solution of potash lye diluted with from 1,000 to 2,000 parts water could still protect iron from rust, but not when diluted with from 3,000 to 4,000 parts water. Saturated lime-water, when diluted three times, that is, holding one 3,000th its weight pure lime, protected iron, but not when diluted four times. Saturated carbonate of natron, when diluted with from 49 to 54 volumes protected iron, but not when diluted with 59 volumes. The finest cast steel was protected perfectly by even less potash.[7]—Iron is perfectly oxidized by being often sprinkled with pure water, and then on being dried and roasted red-hot it loses 14.7 per cent of water, having in fact been a *hydrated* peroxide, or a peroxide positively combined with so much pure water. This hydrated peroxide is also precipitated from an acid solution of iron oxide by perfectly caustic ammoniac. It occurs also pretty pure in nature.[8] The hydrated *protoxide* can be got as a white precipitate by treating a solution of a protoxide salt with the caustic alkali, but with the least air it turns instantly to grey, then green, then dark-blue and then yellow, all mixtures of the two hydrates, and finally in free air to the pure brown hydrated peroxide.[9]

Moist air **rusts** iron yellow, and Bergman makes the rust to consist of 76 peroxide-iron + 24 carbonic acid, which is certainly wrong; Hausmann, of peroxide + water; Thompson and Karsten, of basic carbonate of peroxide + water. Vauquelin has shown that rust, like all other porous bodies, absorbs any floating atmospheric impurities, and therefore often analyzes impurely, especially often exhibiting ammonia. Bonsdorff's numerous experiments show that house rust does not originate from the dampness of the air, even when in maximo, but from contact-electricity passing between oxidized edges and roughnesses and the pure iron, precipitating the moisture of the air and making iron hydrates; other foreign substances, as sulphuretted hydrogen, acetic acid, etc. interfering to cause

[7] Karsten, § 145. [8] Karsten, § 146. [9] Karsten, § 147.

hasten or mediate the process; sulphuretted hydrogen for instance making first sulphuret of iron, which oxidizes itself into sulphate of iron, which decomposes into basic sulphate of the peroxide.[1]—White pig metal can scarcely rust; grey iron easier; bar iron still easier, especially when red-short. Cold-short iron rusts least and slowest. Pure air and polish prevent rust best; also oils that are free from water and do not thicken with time, especially, according to Conté, a mixture of $\frac{1}{5}$ fat oil varnish and $\frac{4}{5}$ rectified turpentine oil; according to Aikin, caoutchouc dissolved in turpentine.[2]—Lacker is used to protect iron from rust. Bluing also in a slow fire protects iron from rust (it is hard to say why) and is much used for nails and tacks. Iron is sometimes "browned" or rusted with acids, to protect it from further rust.[3]

Thompson says the pure peroxide in nature always occurs massive and never crystalline; that all crystalline forms of it have lost half the atom of water and become **dihydrous peroxide,** making nodules of fine needles diverging like a painter's brush, with a right rhombic prism for their primitive form; lustre metallic and silky; constituents Perox. Fe. 91.7, water 8.5. The common fibrous brown peroxide occurs pure in masses, characterized by curved radiation, forming needle ore. The compact uncrystallized forms are seen in pipe and grape ore. True brown hematite is fibrous and silky inside, dark brown outside, scratching dull yellow and making a yellow mud. Before the blow-pipe it blackens and becomes magnetic; with borax in the inner flame, makes a green glass; yields water when heated in a glass tube. It occurs in rocks of all ages and is evidently a second-hand process by leaching or weathering. It forms that immense range of deposits from Vermont to Alabama inside the Blue Ridge, and occurs locally along the outcrops of the limestone iron ores of the coal measures, and in kidney and pea-shaped balls in many later formations. It forms all the bog ores along the Atlantic and Lake seaboards, and most of the iron ores of the Valley of the Mississippi. These uncrystallized deposits have hitherto formed the iron wealth of the United States, as the carbonates form the iron wealth of England; but the crystallized varieties have until lately proved

[1] Karsten, § 148. [2] Karsten, § 149. [3] Karsten, § 150.

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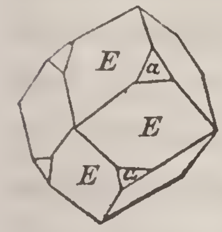
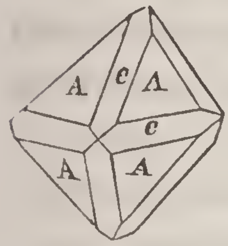
too difficult for furnace use, and therefore have been managed only in the bloomary or Catalan forge. At Gellivara, in Sweden, a mountain of specular ore exists which has never been touched for manufacturing purposes, and perhaps never will be.[4]





The **Proto-peroxide,** *octahedral iron ore, fer oxidulé, ferroferricoxide,* is the **Magnetic** mixture of the protoxide and per (or sesqui) oxide in fixed proportions (as Berzelius first showed) of 4.5 :: 10.0 or 1 to 2; one atom of iron is therefore combined with one and a third of oxygen, or three atoms of iron with four of oxygen, in double groups, $Fe\ O + Fe^2\ O^3$, the odd or unsatisfied atom of oxygen in some way best known to itself producing the polarity of the mass. It contains, therefore, 28.4 of oxygen and 71.6 of iron; whereas the pure per (sesqui) oxide contains 30.66 of oxygen and 69.33 of iron. Magnetic iron ore is therefore *per se* the purest iron ore at man's command, and at the same time is the purest practically and geologically considered, occurring in separate masses in the earth and yielding the best iron in the working. There are however arenaceous deposits of various impurity. Its crystalline form is primarily in cubes, commonly in regular octahedrons (the edges of which are often replaced by tangent planes, sometimes to such an extent as to make the crystal rhombic or garnet dodecahedron), cleaving parallel to the primary faces. Its uncrystalline form is granular or else compact, fracture conchoidal, uneven; color iron black, lustre metallic, scratching and powdering *black* (not *red* like the peroxide or specular ore); hardness 5.5 to 6.5 (scratching fluor spar, and scratched by quartz); specific gravity 5.092, according to Thompson (by others placed as low as 4.4); strongly attracted by the magnet, and sometimes being a magnet itself, exhibiting polarity; infusible before the blow-pipe, and requiring a high heat in the blast furnace; forming with borax or with the biphosphate of soda, in the oxidizing flame, a dull red glass, becoming clear and often yellowish on cooling, and in the inner or reducing flame a bottle-green glass; not fusing with carbon

[4] Whitney, p. 428.

ate of soda. It may be made by passing water over iron heated in a porcelain tube, and forms most of the scales which fall from iron bars passing through the mill rolls. Sulphuric acid dissolves and separates it into the two oxides. Its black streak and its magnetic property are sufficient to distinguish it from the specular ores. The oldest rocks are its home. The Arendale and nearly all the other Scandinavian mines are in massive magnetic ore; the Dannemora and Taburg in southern Sweden and the Gellivara and Kureenavara in Lapland, the Essex, Clinton and Warren county mines in northern New York and the Warwick and Cornwall mines in eastern Pennsylvania are famous for their extent and the quality of iron they produce; and it yields the celebrated Indian wootz. The ore occurs in massive beds in granitoid and gneissoid rocks and primary slates, and in the neighborhood of trap dykes; and in scattered crystals in all metamorphic strata of every age. Some hand specimens are powerful loadstones or natural magnets; Siberia, the Hartz, Elba, and the metamorphic regions of the United States have furnished them. Pliny calls the loadstone *magnes*, from Magnesia in ancient Lydia, where they were obtained by the Greeks. This is the ore which is cleaned before smelting by grinding it to a coarse powder and passing it through barrel-shaped separators armed with rows of magnets. It is said to be frequently *titaniferous* like the peroxide. It ought in fact to resemble in all its geological or structural features the peroxide ores, because the gain or loss of the fourth atom of oxygen which makes the difference between them and the consequent polarizing or depolarizing of the atoms en masse, seems to have been a subsequent, secondary or non-structural process, independent of the original deposition with the iron of other substances.

Iron and Chlorine seem not to influence each other when they meet in the blast furnace; at least, no union of iron with small quantities of chlorine is known.[5] They form two unions. The **protochloride** ($1+1=28$ iron $+$ 36 chlorine $= 64$) is got by heating iron red in a porcelain tube in dry hydrochloric gas, with evolution of hydrogen, as a white crystalline coating to the iron, subliming at a higher heat; or by drying in vacuo a solu-

[5] Karsten, § 201.

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tion of iron in hydrochloric acid, as a grey crystalline compound, soluble in water, not in alcohol, the solutions absorbing oxygen in air, precipitating sesquioxide iron, and retaining yellowish sesquichloride iron, which in its turn, when heated high, gives off chlorine and absorbs oxygen, forming peroxide iron, but when slowly evaporated, forms green deliquescent rhombic hydrated crystals.[6] The reactions of this protochloride or "protomuriate" solution are important in geology, because iron deposited in the salt ocean must fall from such a solution; and we know that the alkalies throw it down as protohydrate of iron, and their carbonates as protocarbonate of iron. These are precisely the two forms in which it appears where carbonic acid has been most abundant, to wit, in the coal measures. Hydro-sulphuric acid, however, gives no precipitate. All this points to carbonic acid as the great agent in the production of our beds of iron ore, under the supposition that the original condition of the iron, the sea solution, was a protochloride.

The **per** or **sesqui-chloride** ($1+1.5=28+54=82$) is obtained by heating iron wire in dry chlorine gas as brownish iridescent scales volatile at a low red; or by dissolving the sesquioxide of iron in hydrochloric acid, as reddish brown deliquescent soluble crystals; alkalies precipitate from this solution hydrated sesquioxide of iron, and so do their carbonates, because carbonic acid does not unite with the sesquioxide, but only with the protoxide.

Iron and Bromine, and **Iron and Iodine**, are equally unknown.[7] But Iron and Iodine may be united by digesting iron filings in mixed iodine and water, as a green solution precipitated by evaporation as green tabular crystals of *protiodide of iron* ($1+1$, or $28+126=154$), fusible to an opaque iron grey very deliquescent mass, soluble in water and alcohol, the solution absorbing oxygen and throwing down peroxide of iron, unless an iron wire is kept in it. Per or sesqui-iodide of iron is got by digesting iron with excess of iodine and subliming to a red volatile deliquescent soluble alloy $1+1.5$ or $28+189=217$.[8] *Pyrosmalite*, see under Iron and Silicon.

[6] *Penny Cyc.*—Iron. [7] Karsten, § 201. [8] *Penny Cyc.*

Iron and Fluorine do not seem to unite when the ore and the spar are smelted together, and for the evil reputation of the latter at some furnaces is substituted so favorable a reputation at others, that it is supposed to insure a firm and particularly good iron.[9]

Iron and Carbon unite in the blast furnace to form *raw iron or pig metal;* and in the refinery fire under a glassy protection from the air, to make *steel;* a very old discovery, but first employed by Birgman (followed by Rinman) to distinguish conditions of iron and show changes from one kind to another; while the still maintained doctrine of phlogiston stood in the way of its best application. Lavoisier's new doctrine of chemical union let in light first in France upon the changes to which iron melted with coal was subject. Scheele discovered in 1799 that black-lead (Reissblei) was carbon, and Vandermonde, Berthollet and Monge in 1786 had shown its influence on iron. Men began to believe that raw iron contained more of it than steel because by reworking steel with it they could produce raw iron. Clouet, Mushet and others then tried to obtain steel by adding carbon to bar iron, but no one could regulate the quantity of carbon and therefore the hardness of the steel. Clouet then tried bodies that contained carbon in fixed combinations with oxygen, that is carbonic acid. Mushet next found that by melting bar iron in clay crucibles without carbon, it was changed with earths and glass fluxes exactly as with carbonate of lime. Tiemann reduced the oxide of iron by carbon to steel, but could not make it certain whether bar iron, steel or raw iron would in a given case result. Probably the principal deficiency in all these experiments was in a careful observance of due temperature, which exerts a predominant influence especially over the constitution of the required raw iron. The only thing yet learned was that according to the amount of carbon used there ought to be obtained from the same ore bar iron, steel and raw iron; but to reduce this knowledge to practice was still a desideratum. Karsten describes the process but says its results cannot be guaranteed. Guyton Morveau, Clouet, Welter and Hachette in 1799 at Paris accomplished the elegant experiment of melting together bar iron and diamonds and produced steel.[1]

[9] Karsten, § 201.

[1] Karsten, § 152. His last quotation is from W. Clay's Remarks of the new mode of producing wrought or malleable iron direct from the ore. Liverpool: 1838.

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It was anciently known that when bar iron was not melted but only made white hot with carbon it became steel. Carbon, if air be excluded, can neither be volatilized nor melted at the very highest temperatures; and yet it will combine at a white glow heat with solid iron, and make *cement steel;* but not at a red glow even in the lapse of weeks. This explains why a white heat must be avoided in reducing raw iron, for at a white heat it would become, not bar iron, but steel.[2] Vismara produced very good steel by conducting oil gas over iron in a close vessel, heated only to 54° to 60° Wedgewood. *Boil-scum*, *iron-scum* (Gaarschaum, eisenschaum), when analyzed is true graphite, black lead, or plumbago; cannot be melted in close vessels; is untouched at ordinary temperatures by acids or alkalies; but burns in the air. Scheele, Gahn and Von Saussure, as well as the later Davy, Allen and Pepys considered it a mixture of pure carbon with pure iron, in proportions about which they could not agree, varying from 4 to 10 per cent iron. But Karsten has proved both natural and artificial graphite to be in itself pure carbon and only mixed mechanically and accidentally with iron, etc.[3]

Analysis discovers **graphite** only in grey pig metal; this when suddenly cooled becomes white iron; and grey again when melted and slowly cooled; so that the difference consists not in the quantity but in the condition of the carbon in the iron. Mushet thought that the hardness of iron steadily increased as its carbon diminished until it reached 1-60th of the whole mass, which lost then its grain, and became silver white. Beyond this point the hardness diminished. His scale (1-15th dark grey iron; 1-20th middle grade; 1-25th white iron; 1-50th steel too hard; 1-90th hard cast steel; 1-100th common cast steel; 1-120th soft cast steel) has gone into all text books, but is entirely incorrect, for soft, granular grey pig can become with no change of carbon a white, hard, brittle metal with a radiated fracture, and again a grey, soft, malleable, granular raw iron. French chemists have suspected oxygen in white pig metal.

[2] Karsten, §§ 135, 153. [3] § 154.

[4] Karsten, § 155, quoting Mushet on the different proportions of carbon which constitute the various qualities of crude iron and steel; in Telloch's *Phil. Mag.* xii. 322-327; xiii. 3-9, 142-149.

But there is none ever found. An analysis finds no trace of graphite in pure white iron and steel, while grey iron always shows it, and yet contains less carbon than the white iron. Bar iron has still less carbon than steel, and when properly prepared not a trace, although it contains earthy bases. Graphite is no oxide but simply carbon in a metallic condition, and so appears in the process of analysis. The difference between white iron, hardened and unhardened steel and bar iron on the one hand and grey iron on the other, consists in the fact that *they* contain more undecomposed carbon and *it* more decomposed or metallic carbon, that is, graphite; as solution in acids shows. The grey, soft, malleable, granular product obtained by simply bringing to a glow white, hard, brittle, radiated pig metal, and so surprisingly like grey iron in the fracture that to appearance nothing but its origin distinguishes them apart, this product gives to an analysis no trace of graphite but only decomposed carbon; and yet is as different from white iron as white is from grey. Three species of carbonized iron must then be formed, one with graphite, and two without; or 1, grey pig; 2, white pig and hardened or brittle steel; 3, reheated white pig and unhardened or malleable steel; three species obtained at will by regulating the heat of the process, and thereby the inner relationships of the carbon and iron. White iron heated only to a glow becomes by slow cooling grey and soft but leaves no trace of graphite in an acid solution; but when white iron is remelted and slowly cooled graphite appears in the acid solution.[5]

Iron cannot take up more than 5.25 to 5.75 per cent of **carbon** in any form, and then becomes specular pig metal. This leafy structure in white iron does not sensibly diminish until the percentage of carbon has fallen to 4.50, below which there is a change from a leafy, radiated, compact structure to a granular; the white color disappearing at the rate the granular structure develops, giving place to a grey which grows lighter and lighter as the percentage of carbon continues to fall through the gradations of steely raw iron—raw iron steel—soft steel—iron steel and steel iron. The so-called *cracked flow* (lückigen Flossen) contains 3.50, and acts like very hard but not hardened steel. The changes of these varieties in the furnace

[5] Karsten, §§ 156, 157.

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under free air are easily explained by the burning out of the carbon; but the change of hardened steel and white pig to soft steel and soft greyish pig by mere glow-heating without air and no change of carbon remains unexplained. Water cast on puddling white iron decomposes and so helps the burning out of the carbon, and the iron is thereby sooner and with a lessened per centage of carbon brought to the same malleable condition that it would reach by a long-continued glow with exclusion of air and no diminution of carbon. The necessity of pressing and working the puddle shows that an essential change is going on in the internal texture.

In the different kinds of **steel** the different **percentages of carbon** have been more closely distinguished. Karsten found different cast and raw steels contain 0.9 to 1.9, cement steel never more than 1.75. Bergman in his important work *de analysi ferri* gives his maximum as 0.8 and his minimum 0.2. No doubt he analyzed cement steel. Karsten found in Upper Silesian cement steel 1.3. Bar iron ought theoretically to hold no carbon, but some does hold as high as 0.8 and then comes very near soft steel. All hard firm excellent bar iron should have not more than 0.1; the softest has 0.2. Burnt iron retains no trace of carbon. Vauquelin gives 0.63 to 0.79 in raw steel. It must be remembered that to obtain with any exactness the percentage of carbon in iron is one of the most difficult tasks the chemist can fulfill.[6]

The **percentage of graphite** in grey iron varies according to Karsten's experiments from 2.57 to 2.75, and the whole percentage of carbon in its graphitic and non-graphitic form from 3.15 to 4.65; less therefore than that of specular white pig metal and less than that of most white pig of the blast furnaces. To get it into the form of graphite needs the highest heat, and that is why oxide ores which make grey iron in the gross make white iron in the small reducing fire with coal, and why bar iron with coal in small fires makes white iron.[7] It is evident that graphite cannot be produced except at the highest heat and cannot be preserved except by slow cooling. Sudden cooling scatters the carbon through the iron which becomes then white iron, the only true chemical union of carbon and

[6] Karsten, §§ 158, 159.

[7] Karsten, § 160.

iron; grey iron being a mixture of slightly carbonized iron with uncompounded carbon or graphite. White iron, smelted at a heat but little above melting point cools again white iron; and white iron long kept at a very high glow heat and cooled slowly has still less power to secrete graphite. If raw iron contains no more carbon than the white iron from which it was made and contains much of it mechanically in the form of graphite, it must be in reality an iron chemically containing very little carbon, even less in many cases than is contained in steel or even in bar iron. Hence we explain many of the **qualities of raw iron,** its granular structure, its low hardness, the slow increase of its hardness in the first degree of heat, its slow approach to a glow heat, its high viscidity and fluidity, its conduct at a glow heat in air, and its readiness to rust compared with white iron. Grey iron is then a mixture of steel-like iron and graphite; and slowly cooled grey soft iron must be a mixture of steel-like iron with a peculiar union of iron and much carbon. White iron and hardened steel will be regarded as similar unions of iron with different quantities of carbon.[8]

Steel may be easily distinguished from iron by dropping upon it a little nitric acid, which will form a black stain occasioned by the carbon which it develops, but it causes a whitish green mark upon iron.[9]

When purified or malleable iron is taken from the reverberatory or puddling furnace and placed under the hammer, it contains a quantity of unreduced and still fluid cast iron (iron and carbon) which spirts forth from between the reduced iron at every blow until the whole is welded into a solid and consistent bar. Cast iron loses more than one-fourth of its weight in conversion into bar.[1] Together with the cast iron however the hammer excludes also a quantity of liquid slag or glass in which the puddlebloom floated while in the puddling furnace.

Iron, Oxygen and Carbon unite to form *Carbonate of Iron* or more properly Carbonate of the Protoxide of Iron, Spathic or *spathose iron*, chalybite, *brown spar*, *stahlstein* and *spherosiderite* or ball ore, called *clay iron stone* or *argillaceous iron ore*, *eisenspath*, *spatheisenstein*, *oligonspath*, etc.

Iron and Carbonic Acid unite only when water takes part

[8] Karsten, § 162 to 165. Rules for the difficult analyses follow in § 166 to 169.
[9] Bache's system of chemistry for medical students, p. 73. [1] Bache, p. 69.

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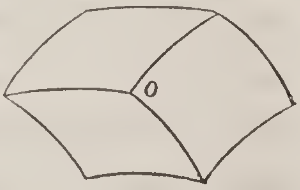
in the compound. The carbonate of the protoxide is soluble in much water and long remains dissolved through free carbonic acid in common temperature; its solubility being further increased and confirmed by the presence of carbonate alkaline salts; but a slow precipitation of yellow-brown basic carbonate of the proto-peroxide takes place, showing itself first as the rainbow-tinted film floating on the surface, so well known to hunters and coal and iron miners by the name of "painted water." *Pure* **carbonate of the protoxide** is white, but becomes yellow as soon as the precipitate dries. It is *spathic iron*, 61.47 iron + 38.53 carbonic acid. Its hydrate if it has one is not known. The **carbonate of the peroxide** is not known either in nature or art, because all carbonate alkaline precipitates of the acid solutions of iron are double, or proto-peroxides mixed with the hydrated peroxide. When a highly concentrated carbonate alkali precipitates a highly concentrated solution of iron-oxide in any acid, the precipitate is itself redissolved and we get a clear brown-yellow crystallizable solution (Döbereiner), once known as the *iron tincture of steel*, out of which grows the *iron tree, arborescontia martis.* When not concentrated no such exhibitions occur and the oxide falls pure and basic.[2]

Crystallized, sparry or spathic, carbonate of iron is rather abundant in primary or metamorphic rocks, frequently occurring with lead and copper; in rhombohedrous[3] and six-sided prisms often with slightly curved faces, cleaving parallel to a rhombohedron of 107°; and also in foliated masses the leaves somewhat curving, the lustre between pearly and vitreous, texture translucent, streak white, hardness 3 to 4.5, specific gravity 3.7 to 3.85 which distinguishes it from the lighter foliated calc spar and dolomite; blackens before the blow-pipe into a very magnetic iron; is



[2] Karsten, § 219.

[3] The obtuse rhomboids approach pretty nearly to the shape of the primary crystal of calcarious spar. Sometimes the angle O is replaced by three planes which when large form a kind of elongated double three-side prism, terminated by the half of the original rhomboid. Not unfrequently the lateral angles of the rhomboid are replaced by tangent planes, which converts the crystal into a regular six-sided prism. Very large crystals of this shape have been found in Cornwall.—THOMPSON, ii. p. 445.

infusible alone; colors borax green; dissolves in nitric acid but scarcely effervesces unless pulverized; and is analyzed into carbonic acid 38.63, and protoxide of iron 61.37 (atoms 1 : 1), with frequently the accidental presence of the carbonates of magnesia and lime and the protoxide of manganese in small quantities.

Junkerite crystals contain about 4. of magnesia (with a variable amount of silica from 8. to 16. in two specimens) according to Thompson, but Dana says the magnesia has proved to be since Thompson wrote also accidental. In *Thomaite* rhombic prisms its specific gravity is 3.1. In *Mesitine spar*, *Breunnerite*, or much of what is called *rhomb spar* and *brown spar*, becoming rusty on exposure, the yellowish rhombohedric crystals contain manganese. *Oligon* spar is a similar yellow or reddish brown rhombohedric crystal with manganese.

Ankerite, *rohwand*, *rohe wand*, *ross zahn*, *horse tooth*, wandstein, wall stone in Stiria and Carinthia, *poratomous lime haloid* of Mohs, is an abundant stratum in mica slate in the eastern Alps, and remind us of some of the more magnesian limestone iron ores of the Ohio and Kentucky coal measures. Thompson gives its analysis as 20.0 carb. iron, 51.1 carb. lime, 25 7 carb. magnesia (3.0 carb. manganese), or 3+8+5 atoms.

Sparry iron ore often contains **magnesia**, as it often contains *lime*. Dana gives the definite proportion of *breunerite*, *bitter spar*, *crown spar*, *mesitine*, *talkspath*, magnesitspath, *pistomesite*, as 58 carbonate of iron + 42 carbonate of magnesia. Sometimes carbonate of manganese, or carbonate of lime is present; and the variations from the normal proportion is very great.[4] Thompson gives under *magnesia carbonate of iron* the sparry ore of Grande Fosse near Vizille, light-yellow, foliated, divisible into large rhomboids, 43.6 protoxide iron (2 atoms) + 42.6 carbonic acid (1 atom) + 12.8 Magnesia, with 1.0 protoxide manganese. It is in fact a mere mixture, as all the carbonate ores of iron are. The dolomite etc. of Dana almost always contain some carbonate of iron, and yet is normally a double carbonate of lime and magnesia in infinitely varied proportions. The carbonates have been always thrown down together in sand and mud and mixed unequally, not segregating from each other but aggregating in various proportions; and the crystallization of the compounds seem to admit almost as much variety as the uncrystallized or amorphous forms.

Uncrystallized carbonate of iron or clay iron is in reality a mixture of the crystallized in the form of an impalpable

[4] Dana, ii. 444.

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powder, with clay and sand, and sometimes coal; hence its variety of form, color, fracture, grain and percentage of material. It occurs in all formations, in scattered balls (sphærosiderite), in plates, and disseminated through thick sandstone strata. If clay predominates it has a downy conchoidal fracture, earthy-grey color, and a specific gravity of a little below 3. If sand predominates, it has a harsh, angular, gritty surface and a specific gravity as high as 3.47. The **practical average of carbonate of iron** in the British coal-measure clay-iron stones is stated by the Penny Cyclopædia at one-third, but Colquhoun's analyses of eight specimens of Crossbasket, Clyde Works, Easterhouse and Airdree blackband,[5] show an average of about 43.0 protoxide of iron and 32.0 carbonic acid making three-fourths of the mass carbonate of iron. Berthier's analyses of nineteen specimens from various coal measure beds in France[6] show an average of 32.7 protoxide of iron and 22.4 carbonic acid, the highest rising to 54.2 protoxide iron and 46.7 carbonic acid, the lowest falling to 13.5 and 24.6. But Thompson shows that in all these varieties there is a mixture merely mechanical of the carbonates of iron, lime and magnesia, with pyrites, clay and coal, in infinitely various proportions. The first analysis given by Colquhoun he readjusts as follows:

COLQUHOUN.		THOMPSON.	
Carbonic acid	32.53	Carbonate of iron	55.697
Protoxide of iron	35.22	Carbonate of lime	15.390
Magnesia	5.19	Carbonate of magnesia	10.899
Lime	8.62	Clay (silic : alumina)	16.060
Silica	9.56	Pyrites (sulph : iron)	1.125
Alumina	5.34	Coaly matter	2.130
Peroxide of iron	1.16	Total	101.301.
Coaly matter	2.13		
Sulphur	0.62		
Total	100.37		

The excess of total being due to deficiency of carbonic acid, for saturating the iron, lime and magnesia

A specimen from the Monkland canal he found to contain 80.2 carbonate of iron, with a specific gravity of 3.505, the purest clay-iron stone he had ever seen except a specimen cf Mushet's blackband yielding:

[5] Thompson, ii., 446.

[6] Ibid. ii., 447.

Colquhoun.	
Carbonic acid,	35.17
Protoxide of iron,	53.03
Lime,	3.33
Magnesia,	1.77
Silica,	1.40
Alumina,	0.63
Peroxide of iron,	0.23
Coaly matter,	3.03
Total, 98.58	

Thompson.	
Carbonate of iron,	85.437
Carbonate of lime,	5.946
Carbonate of magnesia,	3.317
Clay,	2.260
Coaly matter,	3.030
Total, 99.990,	

showing again a loss of 1.4 grain of carbonic acid, provided the iron, lime and magnesia are in a state of saturation.

The American coal measure ores have been analyzed to the number of many hundreds by the chemists of the State Surveys and exhibit the same constituent elements, in a range of proportions of even greater extent. One of the earliest and most extensive suites of analyses published was that made in the laboratory of the Pennsylvania Geological Survey by Dr. Robert E. Rogers and Professor Martin H. Boye in 1839, 1840.[7] The specimens came from the anthracite and bituminous coal basins of Pennsylvania and the analyses separate naturally into three groups, the simple unchanged proto-carbonate ores, the proto-carbonate ores partially reduced to peroxides, and the once proto-carbonate ores wholly converted into peroxides.

The following table A, B, C, shows these varieties arranged according to the percentage in each group. The first column gives the number of the specimen in the report of the State chemists; the second, the percentage of proto-carbonate of iron; the third, that of peroxide; the fourth, that of pure iron. It will be seen at a glance how much wider a practical range of percentage of pure iron the last group has (58.–18.) than the first (40.–19.), the range of the middle group being intermediate (42.–26.).

Lately several hundred analyses have been made by Dr. Peters of the Kentucky State Geological Survey which repeat the same exhibition. An almost insensible graduation of percentages between the highest and lowest limits is seen resembling the change of colors along the solar spectrum and curiously enough with occasional blanks or gaps at irregular intervals like the "dark bands" in the spectrum. These would no doubt diminish with an additional number of specimens, but it is quite

[7] Annual Reports for 1840, 1841.

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possible that they are essentially due to regular interferences, or mark the limits of atomic combinations among the numerous constituents of the specimens. These are protoxide iron, peroxide iron, carbonic acid, silica, potassa, soda, magnesia, alumina, lime, phosphorus, sulphur, carbon and water, all of them confined in their atomic combinations to strict arithmetical limits, while unrestricted as to the mechanical admixtures of their combinations one with another. The following table D, shows the gradual fall of percentage of proto-carbonate of iron through a range of specimens (numbered as in Dr. Peters' reports), with the additional amount of peroxide in the specimens and their total value as pure iron. The analyses stopped at 12.42 because in fact as low as this nothing is called ore that contains iron; the test might have been continued to 1 per cent. It will be seen that the accidental amount of peroxide in the specimen is what determines its value as an ore; the highest percentage of pure iron (52.95) occurring nearly at the bottom of the list where the proto-carbonate element was only 42.26 but the additional peroxide was 46.65.

No.		Carbonate of iron.		Peroxide.	Iron.
37	A.	84.24			(39.93)
1		80.97			(39.09)
14		79.70			(38.05)
15		76.30			(37.03)
48		74.50			(35.98)
6		72.00			(36.00)
44		71.19			(34.37)
40		69.00			(33.32)
4		67.80			(33.90)
3		65.30			(32.60)
49		63.20			(30 52)
42		55.82			(26.95)
58		54.33			(25.34)
28		45 50			(22.05)
39		45.30			(21.86)
23		44.79			(27.05)
36		43.89			(20.79)
2		39.82			(19.21)
38	B.	73.94	+	10.36	(42.22)
43		73.81	+	4.24	(38.59)
57		68.32	+	15.54	(32 95)
45		67.20	+	7.48	(37 24)
26		66.67	+	2.55	(33.96)
56		66.37	+	20.49	(45.64)
52		60.90	+	12.60	(38.22)
50		58.00	+	8.45	(45 92)
47		56.90	+	24.90	(44.87)
55		56.83	+	13.21	(36.11)
46		55.10	+	9.50	(34.72)
54		50.48	+	12.79	(32.77)
33		48.33	+	15.06	(33.35)
25		42.38	+	21.32	(34.86)
27		39.54	+	14.57	(32.52)
31		35.13	+	28.10	(41.88)
32		31.53	+	31.31	(37.14)
30		31.07	+	14.37	(25.05)
5		26.02	+	19.36	(26.39)
11	C.			83.00	(58.10)
21				80.12	(56.07)
12				79.20	(55.44)
17				78.60	(54.75)
22				78.22	(55.02)
20				76.10	(53.27)
19				65.20	(45.64)
24				26.69	(18.51)

D.	Carbonate of iron.		Peroxide of iron.		Per cent of iron.
a. 153	86.10	+	.23	=	41.42
b. 153	85.44	+	.23	=	41.00
97	79.72	+	4.52	=	41.26
38	78.51	+	5.57	=	41.80
447	78.35	+	3.36	=	39.20
151	74.46	+	1.15	=	36.80
199	73.13	+	4.94	=	38.81
37	72.86	+	7.42	=	39.42
118	70.60	+	5.42	=	37.53
75	70.39	+	13.14	=	43.20
482	70.27	+	10.16	=	40.70
409	70.20	+	9.92	=	37.45
710	69.96	+	2.64	=	35.64
410	68.46	+	3.41	=	35.45
479	67.84	+	5.89	=	37.46
449	67.72	+	6.99	=	37.60
443	67.50	+	1.28	=	33.12
411	66.01	+	2.67	=	33.05
7	65.96	+	7.19	=	36.90
120	65.93	+	8.63	=	37 55
416	65.13	+	7.78	=	37.04
150	64.90	+	7.41	=	36.54
148	64.87	+	4 39	=	34.18
153	62.59	+	14.79	=	40.26
149	62.42	+	3.38	=	32.52
49	62.24	+	2.68	=	31.93
656	61.73	+	——	=	26.84
311	60.49	+	5.25	=	22.57
390	60.40	+	21.38	=	43.82
100	60.36	+	2.33	=	30.46
488	57.59	+	7.77	=	32.62
312	56.92	+	14.14	=	37.10
50	56.58	+	4.86	=	30 70
294	54 42	+	30.24	=	47.51
152	54.32	+	6.75	=	31.17
493	53.64	+	7.71	=	31.30
452	53.02	+	20.73	=	35.60
600	52.60	+	13.64	=	42.72
633	51.24	+	9.42	=	31.62
407	47.97	+	10.66	=	30.77
445	47.84	+	——	=	41.63
60	46.40	+	8.28	=	28.20
757	45.12	+	16.46	=	33.86
440	43.90	+	23.06	=	35.02
121	42.68	+	17.02	=	32.37
632	42.26	+	46.65	=	52.95
74	41.98	+	44.66	=	43.65

No.	Carbonate of iron.		Peroxide of iron.		Per cent of iron.
708	33.50	+	5.50	=	29.69
406	32.29	+	5 01	=	19.10
475	28.09	+	14.42	=	23.62
61	23.54	+	——	=	11.35
124	17.84	+	25.08	=	25.30
122	17 42	+	24.80	=	25.68
14	14.26	+	16.17	=	18.55
24	12.42	+	14.07	=	15.86

The principal ingredient in these carbonate ores is silica, not as combined, but as an admixture. Table E is a selection of a few of these analyses in the order of their silica contents.

E.

No.	Carb. of Iron.		Peroxide.	Iron.	Silica.
312	56.92	+	14.14	=37.10	16.15
410	68.46	+	3.41	=35.45	19.65
757	45.12	+	16.46	=33.86	19.92
475	28.09	+	14.42	=23.62	19.98
600	52.60	+	13.64	=42.72	20.78
443	67.50	+	1.28	=33.12	21.45
708	33.50	+	5.50	=29.69	21.48
311	60.49	+	5.25	=32.57	21.82
440	43.90	+	23.06	=35.02	22.15
656	61.73	+	0.00	=26.84	27.14
633	51.24	+	9.42	=31.62	32.48
406	32.29	+	5.01	=19.10	51.55

Alumina is a much less significant element; but in some earthy ores its percentage rises to 5 or 10 per cent. Carbonate of lime on the contrary graduates so high as to convert the iron ore into a ferruginous limestone and that in a geographical distance of a few hundred yards. Table F will show this, the high increase of lime necessarily involving the low percentage of iron.

Iron and Carbon.

The percentage of carbonate of magnesia runs up to 10 and 15 per cent in some cases, but commonly keeps down to 5 or less. Phosphoric

F.

No.	Carbonate.		Peroxide.		Pure Iron.	Carbonate of Lime.
151	74.46	+	1.15	=	36.80	2.45
152	54.32	+	6.75	=	31.17	3.87
708	33.50	+	5.50	=	29.69	4.58
124	17.84	+	25.08	=	25.30	5.97
6.153	85.44	+	.23	=	41.00	5.94
488	57.59	+	7.77	=	32.62	6.28
407	47.97	+	10.66	=	30.77	7.25
24	12.42	+	14.07	=	15.86	18 48
475	28.09	+	14.42	=	23.62	29.37
60	46.40	+	8.28	=	28.20	32.15
122	17.42	+	24.80	=	25.68	32.85
14	14.26	+	16.17	=	18.55	35.15
61	23.54	+	0.00	=	11.35	67.33

acid seldom reaches 1 per cent, but in one instance Dr. Peters found 29.49 phosphate of lime where the carbonate of lime was 18.48, silica 16.07 and pure iron only 15.86. The carbonate of manganese is always present ranging between 1 and 3 per cent but sometimes going up to 5 and 6.

Blackband is the above admixture of carbonates with a notable percentage of uncombined carbon or **coaly matter,** bitumen, or the coal-gas oils. Of eight varieties of clay ironstone from the neighborhood of Glasgow analysed by Colquhoun not one had less than 1.5 coal; Mushet's blackband had 3.03; and this is the one which also contains most carbonic acid, 35.17, and most of it in combination with iron (carbonate of iron 85.437).[8] Dr. Colquhoun found the amount of bituminous matter in a range of blackband ores vary from 1.86 to 17.38 per cent. The Kentucky blackband ores vary in bituminous matter from 1 to 11 per cent.[9]

Thompson gives a *phosphatic carbonate* of iron analyzed by Karsten in the Ann. des Mines, iii. 253, 1827, occurring in beds in the Jura limestone at Vignes and used by the iron smelters on the Moselle, of a deep greenish blue (not unlike chamoisite), oölitic, grains not larger than a millet seed, magnetic, specific gravity 3.71, dissolving slowly with effervescence in muriatic acid, depositing silica which will not gelatinize and therefore is only accidentally present, probably as an original loose sand enveloped by the mineral material, as the peroxide of iron envelops the oölitic Upper Silurian ore of Formation V. Karsten's analysis is 41.12 peroxide iron, 30.00 protoxide iron + 11.87 carbonic acid, 3.38 phosphoric acid, 7.00 silica, 2.14 lime, 2.90 water, 0.77 magnesia, the last four being impurities, and the first four arranged

[8] Thompson, i. 446. [9] Dr. Peters, K.S. Vol. i. pp. 365.

as 6 atoms carbonate iron + 1 atom diphosphate iron + 3 atoms of (1 pro- + 1 per-) oxide iron.[1] Nothing could show better than this instance the heterogeneous and accidental constituency of these carbonate ores of iron as they occur in all parts of the globe and in formations of every age.

Hydrous Carbonate of Iron, or **Brown Spar,** according to Thompson is a *hydrous carbonate of the protoxide and peroxide of iron*, in dirty, entangled, rhomboidal crystals, pearly, dull, opaque, brittle, H. 3.25, S. G. 3.404, composed of 30.27 protoxide + 18.5 carbonic acid, and 57.65 peroxide + 8.30 water, with 4.75 protoxide of manganese thrown in, the original carbonate of iron having become partially peroxidized and then hydrated by water taking the place of an equivalent quantity of carbonic acid set free.[2]

Dana's Brown-spar is a carbonite of manganese, with a small variable quantity of carbonate of iron and other impurities, called *diallogite*, etc. Its resemblance to iron is remarkable in the case of the layer two inches thick at the bottom of the Irish bog at Glendree, county Clare.[3] This is an exhibition of importance in discussing the presence of the hydrated peroxide beds of iron ore in the coal measures.

Iron and Boron combine with difficulty when borate of iron is heated to redness in a stream of hydrogen. Lassaigne got 77.43 iron + 22.57 boron thus as a silver white brilliant mass protecting itself from acid action by coating itself with its own disengaged boron.[4] *Lagonite*, a yellow ochre incrusting the Tuscan lagoons, contains 37.8 (36.26) peroxide iron, 49.5 (47.95) boracic acid, 12.7 (14.02) water.[5]

Iron and Silica (sand) unite closest at a high heat. Berzelius was able to make **iron and silicium** unite by cementing iron filings and powdered sand in coal dust; and in the same way as iron and carbon unite. He found no injury done to the malleability of the iron, but only that its softness depended on the thoroughness with which the carbon was worked out of it. The more silicium the less the specific gravity of the alloy. In dissolving in acids it gives out more hydrogen than the purest bar iron does, because iron can take never more than 30 per cent oxygen, but silicium can take over 50, and therefore can decompose more water. Stromeyer made numerous alloys with from 2.25 to 9.30 per cent of silicium, but unfortunately the alloy could not be studied pure because the carbon increased in proportion with the silicium; so much however seemed clear that no harm was done either to the tenacity or to the ductility of the iron. Karsten's experiments in Upper Silesia, on a grand scale with pure quartz sand said the same thing. In the refinery the silicium is mostly separated and slagged off. The rule does not always hold good that grey iron holds more silicium than white (because produced at a higher heat); much depends on the

[1] Thompson, i. 474. [2] Thompson, i. 470. [3] Dana, ii. 447. [4] *Pen. Cyc.* [5] Dana, ii. 395.

Iron and Silicon.

preparation. Raw iron seldom holds less than 0.4, and may hold more than 3.0 per cent silicium. Other things equal, hot blast pig holds at least 0.3 per cent more than cold blast. Bar iron and steel may vary between 0.001 and 0.1 but at 0.05 they should lose their reputation. Boussingault showed that in bar iron and steel silica became silicon (silicium) even at cement heat and combined like carbon with the iron. But if pure iron is melted in close crucibles it takes up silicon and grows more fusible thereby;[6] in Hessian crucibles it received 1.0 silica or 0.54 silicon. But as Karsten remarks small experiments too often deceive. Silicon cannot make such steel as carbon can, although it hardens iron, for experiments in the gross certify that it injures the tenacity of iron very seriously, and is the cause through imperfect puddling of so much rotten-short (faulbrüchig) bar iron. Even 0.37 silicon is enough to ruin the tenacity of iron. Karsten instituted numerous analyses of such iron and found nothing present but silicon except minute and unimportant traces of phosphorus. He convinced himself that silicon was far more injurious in this particular respect than phosphorus. No original pig metal is destitute of it, more or less. Carbon the same, that pig metal which has most silicon is the hardest and the brittlest. Silicon never is seen in the blast furnace hearth, but is always in the iron. When pig metal that has much of it cools, the silicon partly separates itself as a pure white oxide (silica) sometimes beautifully radiant or stellar or uniformly fibrous; curiously sometimes in the cavities and vesicles of the pig metal; but the metallic silicon never appears. Even when the oxide, of titanium is reduced, the silicon still appears only as an oxide, not seldom in beautiful parallel or diverging crooked and straight fibres of mingled white and silky lustre even to the depth of half an inch pure silica. The greatest per centage of silicium (silicon) Karsten ever found in raw iron was 3.46, and that under rare circumstances. Even 1.00 (=2.00 silica) is remarkable. Coke iron holds more than charcoal iron usually.[7] In the analysis only the 5th or 6th of the silica

[6] Mushet had already discovered that bar iron melted with pure quartz and became harder and more brittle and steel like.

[7] §§ 237, 238.

remains in the coaly residuum; the rest is dissolved and lost in the acid.[8]

Hydrous di-silicate of iron, *sideroschisolite* 75·5 protoxide iron + 16.3 silica + 7.3 water + 4.1 alumina (=2+1+$\frac{3}{4}$ atoms) is a pure velvet black small (microscopic) tetrahedral, specular, splendent, opaque crystal, lining cavities in magnetic pyrites and sparry iron ore, powdering to a leek green, hardness 2.5, specific gravity 3, fusing easily to an iron black magnetic bead (the crystals when held to a candle-flame lose the velvet look and become iron black and are strongly attracted by the magnet), dissolves completely in muriatic acid to a greenish yellow solution. *Chamoisite* is a **bihydrous disilicate** mineral found in thick and numerous local deposits, in the ammonite limestone of Chamoisin (lias ?), granular or earthy, dark green grey, very magnetic, opaque, irregularly fracturing, scratched by steel, specific gravity 3 to 3.4, and composed of 50.5 protoxide of iron + 12.0 silica + 14.7 water and bitumen (+14.4 car. lime, 6.6 alum, 1.2 car. mag.) =2+1+2 atoms, differing from the last species in containing twice as much water. Dana calls it a mixture of magnetic iron and hydrous silicate of alumina.[9]

Silicate of iron, *iron chrysolite*, *eisenperidot*, *fayalite*, 70.45 protoxide iron + 29.55 silica occurs in an Irish dark brown foliated magnetic crystal with the addition of 1.78 manganese. The **hydrous silicate**, or *cronstedite*, is a tourmaline like brown black (streak dark leek green) massive kidney form, foliated, vitreous, opaque, elastic, regularly six-sided prism, frothing a little without melting before the blowpipe, non-magnetic, and containing 58 protoxide iron + 22 silica + 10.7 water with protoxide manganese and magnesia accidentally =1+1+1.[1]

A *bihydrous bisesquisilicate* of iron called Hedenbergite occurs near the Zunaberg copper works in Sweden, with 35.25 protoxide iron+40 62 silica+16.05 water +3.37 lime, etc.,=1+2.5+2 atoms; in greenish black massive shining plates.[2]

Chloropal is another curious quinto or ter-silicate of iron according to the different analyses 33 protoxide+46 silica or 26 peroxide+53 silica.[3] It is a greenish yellow massive earthy conchoidal fragile mass remarkable for breaking up into a kind of parallelopiped, the upper end and two adjoining edges having an opposite magnetic polarity from the lower end and two other edges.

Hydrous sesquisilicate of iron, *Thraulite*, *Hisingerite*, *Gillingite*, a black nodule, powdering brownish yellow, conchoidal, splendent, opaque, brittle, not very heavy, giving out water before the blowpipe, fusing at the edges, becoming magnetic, contains 44.39 peroxide iron, 36.30 silica, 20.70 water (Hisinger; or 31. 50. 19. Kobell), the specimens not being free from magnetic pyrites.[4] Dana gives its composition as 34.9 per+23 6 protoxide iron, 29.7 silica, 11.8 water in one instance, varying in others. It belongs apparently to the variable hematized carbonate nodular ores. *Achmite* is a soda silicate crystal (in granite) of an earthy fracture, vitreous and translucent, scratching glass, and containing 4 atoms bisilicate iron+2 tersilicate soda+1 bisilicate manganese, lime, magnesia and alumina.[5] *Crocidolite* or the *blue iron stone of the Cape of Good Hope*, is both compact and asbestiform, lavender blue, opaque, elastic, hard 4, specific gravity 3.2, melting easily to a frothy glass, attracted, and distinguished from asbestos by each single hair melting readily when held to a spirit flame; contains from 34 to 40 protoxide iron, 50 silica, 5 to 7 soda,

[8] § 239 which gives the best method of analysis. [9] Dana, ii. 299.

[1] Thompson, i. 461. [2] Thompson, i. 462.

[3] Thompson, i. 464. Dana gives 40.5 peroxide+45.9 silica+13.7 water, relating it to the hydrous silicates of alumina, ii. 337. [4] Thompson i. 478. [5] Thompson, i. 480.

3 to 6 water, 2.5 magnesia, 1.5 lime and a trace of manganese.[6] *Arfœdsonite*, "ferruginous hornblende," is a pure black, green edged, four-sided prism, containing 35.14 peroxide iron, 50.50 silica, 8.92 sesquiox-mang. etc.[7]

Iron and Phosphorus.

Knebelite[8] is a grey spotted uneven glistening opaque hard brittle mass (3.714) infusible pure, fusible with borax to an olive green bead, 32 protoxide iron, 32.5 silica, 35 protoxide manganese, or 1 silicate iron+1 silicate manganese.—A ferruginous *tephroite*, Dana.

Pyrosmalite from Bjelke iron mine emits a strong odor of chlorine when heated before the blowpipe, a liver brown, internally light greenish yellow, splintery, pearly, translucent to opaque, rather brittle six-sided prism (4.5) (3.081) 35.48 peroxide iron, 35.85 silica, 23.44 sesquioxide manganese, 3.76 chlorine, 3.60 water, 1.21 lime.[9]

Cummingtonite, (an asbestiform *tremolite*, Dana) found at Cummington Massachusetts, is a grey white silky opaque bunch of diverging needles, infusible per se, (2.75) (3.2014) 21.67 protoxide iron, 56.54 silica, 7.80 protoxide manganese, 8.44 soda, 3.18 water, the bases being in a state of tersilicates.[1]

Nontronite (chloropal, Dana) from the celebrated manganese beds of Peregueux, Dordogne, disseminated as nodules never pure, frangible irregular coated with manganese and mixed with yellow clay, polishing like serpentine; when pure straw-green, dull, unctuous, friable, (2), non-odorous, non-magnetic, 29 peroxide iron, 44 silica, 18.7 water, 3.6 alumina, 2.1 magnesia, 1.2 clay.[2]

Polylite so called from its numerous constituents forms a bed $\frac{1}{4}$ inch thick in magnetic ore at Hoboken, New Jersey, consists of black plates, vitreous, splendent, brittle, (6.25) (3.231) infusible per se, fuses with borax slowly to a black transparent glass, 34.08 protoxide iron, 40.04 silica, 11.54 lime, 9.42 alumina, 6.6 protoxide manganese.[3]

Iron and Phosphorus unite in the reduction of phosphate of iron with coal at a brown red heat, or by heating to a bright red iron filings and phosphoric acid with coal. Glowing peroxide of iron with a large quantity of phosphorus makes phosphate of iron in the form of slag. Pelletier is wrong (according to Karsten) in thinking he thus gets also phosphuret of iron. Phosphorus added in successive doses to iron filings kept at a red heat in a carefully covered crucible makes a pure phosphuret of iron, a very brittle, greyish white, fusible mass; unalterable in close vessels and at a strong heat, (but, according to Pelletier, giving off phosphorus when heated to a glow in air in a muffle and remaining a peroxide of iron mixed doubtless with some phosphate of iron;) not magnetic and not attacked except by boiling nitric and nitro-muriatic acids; the only *determinate*

6 Thompson, i. 480.
7 Thompson, i. 481.
8 Thompson, i. 484.
9 Thompson, i. 492.
1 Thompson, i. 493.
2 Thompson, i. 494.
3 Thompson, i, 496.

union of the two substances known, consisting of 2 weights of iron (56) and 1 of phosphorus (16), or 77.14 iron + 22.86 phosphorus. Phosphorus however seems to unite with iron in lower and variable quantities. This *di-phosphuret* has never yet been found in nature; but many ores of iron are made cold short by the presence of the *phosphate* which coal ashes also and many earths contain, and therefore phosphorus is found in all iron and in very different relations.

The **perphosphuret of iron,** 3 equivalents of iron (84) + 4 of phosphorus (64)=148) is obtained by the action of phosphorus on persulphuret of iron at a moderate heat, and resembles the diphosphuret in its properties.

The **phosphate protoxide** of iron forms a white, pulverulent precipitate, *becoming blue* in time in the air, as a supposed (but not proved) basic phosphate of the peroxide and phosphate of the proto-peroxide, occurring frequently in nature. The blue and white colors may be caused by water. Water does not dissolve the phosphate protoxide, but acids do easily (even acetic acid), and then dilution or an alkali will throw it down. Hence the prescription for ridding iron ore or a sulphate of iron of phosphoric acid, by dosing it with water and a little alkali and letting it stand; the white phosphate will gradually appear at the bottom, and afterwards turn blue; but the quantity contained must not be too small; the process is good for nothing in quantitative analysis.[5]

Mullicite crystals from Mullica Hill in New Jersey, and from Brazil and Isle of France, are cylinders two inches long by half an inch in diameter, incrusted with yellowish red sand, which also occurs dispersed through the cylinders as if they were made of loose sand (of quartz tinged with iron), bluish black, opaque, splendent, vitreous and made up of needles radiating from the central axis, sectile, hardness 1, specific gravity 1.787, protoxide iron 42 65, phosphoric acid 24.00, water 25.00 (2 : 1 : 4 ?), grains of quartz sand 7.90, making it a crystallized *diphosphate*. Vauquelin's analysis gives 2½ atoms of water, and Berthier's 2 instead of 4.[6] *Anglarite* has less phosphoric acid; *Triphyline* contains as much manganese as iron, and some lithia.

Phosphate of iron, *Vivianite, fer phosphaté, blue iron earth, blaue eisenerz, eisenblau, fer azuré, glaukosiderit, eisenphyllit, mullicite*, are names given to the same mineral by Dana, but Thompson makes four species of phosphated peroxide of iron, Diphosphate, Mullicite, Native prussian blue and Vivianite, in atomic proportions of protoxide of iron to phosphoric acid as follows: 2 : 1 1.66 : 1 1.5 : 1 1⅓ : 1, but he confesses that their analyses are attended with peculiar difficulties.[7]

Vivianite occurs in modified oblique crystals, cleaving well one way, and also radiated, kidney-shaped, globular or as a coating, deep blue to green, according as

[4] *Pen. Cyc.* [5] Karsten, § 226. [6] Thompson, i. 453. [7] Ibid. p. 454.

Iron and Phosphorus.

you regard the crystal, pearly or vitreous, translucent or transparent, becoming an opaque dingy indigo by exposure and before the blowpipe white, then melting to a black magnetic enamel, flexible when thin, hardness 1.5 to 2 with bluish streak, specific gravity 2.66, composition *prot*oxide iron 42.4, phosphoric acid 28.7, water 28.9 (Stromeyer says 41.2, 31.2, 27.5) dissolves in nitric acid and gives water in a tube. It is found with iron, copper, tin, sometimes in clay and in bog-iron ore, and often fills up the interior of fossils.[8]

Subsesquiphosphate, *blue iron earth*, or *native prussian blue* occurs in nests in bog-iron ore and in mosses, as a greyish white earthy powder exposing to a smalt blue, slightly soils the hand, feels harsh, grows reddish brown before the blowpipe and makes a magnetic black globule, contains 43 to 47 protox. iron, 30 to 32 phos. acid, 20 to 25 water. Rammelsborg makes some of the iron peroxide.[9]

The **Phosphate peroxide** of iron is precipitated from the protoxide salt by a phosphate alkali, also as a white powder which does *not* change blue, but when heated to a glow turns *brown* by losing part of its water. It dissolves very readily in the mineral acids and falls from them again by addition of alkalies. It is insoluble in water and vinegar. Infusible caustic alkalies turn it basic, when it outwardly resembles peroxide of iron, and dissolves in mineral acids but not in vinegar. An acid solution, containing phosphoric acid and peroxide iron in such relations as to form it, will drop a basic peroxide salt on addition of alkalies without retaining a trace of the acid. Even if the solution holds lime and the alkali used is corrosive sal ammoniac the acid still combines solely and wholly with the oxide and the lime remains dissolved. But if the protoxide instead of the peroxide be present the acid takes the lime and falls.[1]

Kraurite (green iron-stone), *alluaudite*, *melanchbor*, *beraunite*, are **phosphates of the peroxide** of different colors; *Cacoxene*[2] contains alumina and radiates in beautiful tufts of yellow-brown, resembling Wavellite, and also Carpolite, and occurs with tertiary ores in Bohemia, and with primary ores at Stirling New Jersey; *Carphosiderite* is a kidney-shaped yellow phosphate from Greenland.[3] *Delvauxene* is a rare waxy yellowish black or reddish earth composed of 35.80 peroxide iron, 15.90 phosphoric acid, 48.3 water. *Beraunite* is altered *vivianite* found in limonite, foliated, radiated, hyacinth brown with ochre yellow streak, hydrous phosphate of peroxide iron. *Dufrenite*, *Kraurite*, *grüneisenstein*, *green iron ore* is a silky radiated fibrous subtranslucent drusy ore, 63 peroxide iron, 28 phosphoric acid, 9 water. *Carphosiderite* is a kidney, resinous straw-yellow, greasy, phosphate of iron and manganese and zinc occurring in fissures in mica slate in Labrador. *Cryptolite* is a crystal of phosphate of cerium with only 1.5 per cent of iron; *Phosphocerite* is identical with it, with twice as much iron; in both the iron is accidentally present. *Zwieselite*, *eisenapatit*, is a greasy-looking, clove-brown, imperfectly conchoidal fracture phosphate of iron (41.42) and manganese (23.25). *Triphyline* is a greenish grey subresinous semitranslucent phosphate of protoxide iron (49.16) manganese (4.75) and lithia (3.45); *Tetraphyline*, *Pseudotriplite*, *Hete-*

[8] Dana, Manual, p. 229. [9] Dana and Thompson. [1] Karsten, § 226.

[2] *Cacoxenite*, *childrenite*, occurs also in carbonate clay-iron stones of the coal formation at the Hebetk mines in Bohemia and yielded to Steinmann 36.32 peroxide iron + 17.86 phosphoric acid + 25.95 water and fluoric acid (with 8.90 silica, 10.00 alumina); but to Richardson 43.1+20.5+30.2 (with 2.1+1.1 lime, 0.9 magesia)=a diphosphated peroxide of iron + 6 atoms of water.—THOMPSON, i. 477. [3] Dana, Manual, p. 230.

rosite, *Hureaulite*, *Alluaudite*, *Norwich mineral* all come under the same head. *Triplite* or *ferruginous phosphate of manganese*, *pitch-iron ore*, *eisenpecherz*, 33.6 protoxide iron, 33.2 phosphoric acid, 33.2 manganese,[4] occurs at Limoges in France in granite.[5] *Hetopezite* is a greyish green crystal becoming blue on exposure, foliated, hard enough to scratch glass, and containing 35.00 peroxide iron, 41.78 phosphoric acid, 16.20 protoxide manganese, 4.40 water; or 2 atoms phosphate iron + 1 atom diphosphate manganese + 1 atom water.[6]

Phosphorus makes iron cold-short, but hastens its welding or balling, and does not injure its quality at any grade of heat, but softens it, gives out at glow heat neither vapor nor odor, but diminishes its tenacity on cooling,[7] and the cold-short quality increases with the increase of phosphorus. Other elements make iron cold-short, but phosphorus is undoubtedly the greatest and commonest cause; yet if its influence over iron in this direction were as great as that of sulphur in the direction of the red-short evil, few lands could produce a firm and durable iron. Karsten produced bar irons of all grades of cold shortness out of raw iron made from meadow ore (bog ore) and found that 0.3 per cent of phosphorus produced not the least apparent diminution of tenacity; the iron was of the very best and firmest kind. Even with 0.5 bar iron bore the hammer test; but not with 0.6; even then it would bend at right angles and bear throwing over the anvil pretty well; at 0.66 it begins to show itself properly cold-short, but will still bear bending well up to 0.75; many cracks appear at 0.8, and at 1.0 it will not bear bending to a right angle at all, and then like all other kinds of iron with 1.0 per cent of phosphorus is extraordinarily brittle and fit for very few purposes. Karsten never found a bar iron free from phosphorus; but until the proportion reaches 0.50 no injury results. Seldom more than 0.05 per cent of phosphorus gets through raw into bar iron from ores which are not evidently mixed with phosphates of the salts of iron. What little does—even up to 0.3 per cent—only seems to harden the iron without interfering with its tenacity in any observable degree.[8]

The **cause** of phosphorus making iron cold-short Meyer & Bergman first discovered. Treating cold-short ore or iron with concentrated sulphuric acid, washing and quietly cooling, they got a powder white or bluish, infusible, soluble in acids, decom-

[4] =1+1+1 atoms, or 1 atom diphosphate iron + 1 of diphosphate manganese.—Thompson.

[5] Dana. [6] Thompson, i. 474. [7] Karsten, §§ 184, 185, 186. [8] Karsten, §§ 187, 188.

Iron and Phosphorus.

posed by alkalies, smelting easier than raw iron, and heated with coal giving **water-iron** (hyderosiderum) which when alloyed with malleable iron made it cold-short. Meyer, Klaproth and Scheele discovered afterwards that water-iron was no new and separate metal, but that the white powder was a phosphate, and Bergman found from 0.10 to 0.16 per cent of it in all the cold-short iron he tried. But Vauquelin still later showed that the use of sulphuric acid exhibited but a small part of the phosphorus present in cold short iron. Karsten's experiments on raw iron led him to believe that 0.4 per cent of phosphorus was the maximum of the *imperceptible* loss of tenacity; even 0.5 making its weakness very apparent, when dashed upon an anvil. Although phosphoric acid is common in the brown and yellow iron-stone ores of all formations and other ores to a less degree, and in combination with lime (as in apatite), its passage into pig and bar iron would not be to be feared if it acted like sulphur;[9] but it does not; not a trace of it is to be found in the furnace slag; the whole of the phosphoric acid passes over as phosphorus into the iron, as Karsten showed in 1827 and as the French chemists afterwards acknowledged. Ores therefore with a considerable mixture of phosphate oxides or phosphoric acid should be as much as possible avoided. On the other hand phosphorus (unlike sulphur) goes for the most part into slag with the oxide of iron in remelting pig metal in open hearths with a strong blast; refined-iron holds therefore less phosphorus (and more sulphur) than raw iron.[1]

The threefold union of **iron, carbon** and **phosphorus** is very uncertainly understood. Carbon and phosphorus are not known to unite. An overdose of phosphorus, like an overdose of sulphur, seems to arrest the characteristic influence of carbon on iron. A quantity insufficient to prevent the usual modification of the iron by the carbon only makes the carbonized iron more fusible; brings bar iron and steel sooner to a weld and yet does not destroy malleability (owing perhaps to the fact that phosphor-iron holds heat better than sulphur-iron), especially at a very high heat, but shows its cold-short influence afterwards.

[9] As described in Karsten, § 181.

[1] Karsten, §§ 189, 190. In 191 he gives the method of analysis.

Raw iron phosphorus makes quicker melt, quieter flow and slower cool; thinner, and therefore better adapted for hollow ware casting. Phosphorus for the same reason also opposes the production of the graphite form of carbon in raw iron even more than sulphur does. Ores which contain apparently no phosphorus will make raw iron containing at least 0.2 phosphorus. Karsten's highest percentage in raw iron made from bog ore was 5.6; not high enough to show the maximum when raw iron ceases to be useful for castings. Phosphor-iron is disposed to come out of the cupola *white* instead of grey, and therefore it requires in remelting a high cupola.[2]

Iron and Sulphur unite readily and rapidly. Sulphur enables iron to melt at a strong red heat. Equal parts kept melted in a covered vessel for some time make a perfect alloy attracted by the magnet. Various mixtures of sulphur and iron can be obtained according to the different grades of temperature employed. The less the sulphur the higher must be the heat. Two direct specific unions are recognized. Others are made by reducing sulphate of iron with carbon or hydrogen, or by reducing oxide of iron by sulphuretted hydrogen. Determinate alloys occur in nature, and others which are supposed to be mixtures of these alloys in different proportions. Arfoedson says that an alloy of 4 weights of iron with 1 of sulphur is got by heating to a glow in a glass tube in a stream of hydrogen the basic sulphate of the peroxide of iron—as a black grey powder, becoming metallic by rubbing against hard bodies, and magnetic, giving out 7 parts hydrogen and 1 sulphuretted hydrogen when dissolved in acids and containing according to Berzelius 93.1 iron + 6.9 sulphur. He obtained another alloy of 1 to 1, by heating anhydrous sulphate of the protoxide of iron in a stream of sulphuretted hydrogen—as a magnetic powder containing 77.13 iron + 22.97 sulphur. Karsten found in the Gleivitz furnace-slags some slightly magnetic crystals of sulphuret of manganese + sulphuret of iron, both metals combined with equal weights of sulphur. Berzelius describes a third alloy of 1 to 3, produced when pure anhydrous peroxide of iron is kept at 212° in a stream of sulphuretted hydrogen until steam is no longer pro-

[2] Karsten, §§ 198, 199, 200.

Iron and Sulphur.

duced—grey, yellowish, polishing bright, fixed in air, distilling into the last mentioned alloy of 1 to 1, and consisting of 52.9 iron + 47.1 sulphur.

The **Protosulphuret of Iron** so called, is a union of iron with sulphur (1 to 2), obtained by melting iron and sulphur together and by various chemical reactions, as a yellow magnetic mass, consisting of 62.77 iron + 37.23 sulphur. It has not yet been found in nature pure, but is tolerably well represented by the so called **magnetic pyrites,** and very nearly approached by the pyrites found in coal mines, which deflagrates in moist air so rapidly, producing vitriol, and evolving heat enough sometimes to fire the coal. Magnetic pyrites in nature, is variously composed, being in fact a variable mixture of true or artificial magnetic pyrites (1 : 2) with the bisulphuret or Iron Pyrites (1 : 4). It therefore corresponds with the natural magnet or mixture of the protoxide and peroxide of iron. Stromeyer found in a Treseburg specimen 59.85 iron + 40.15 sulphur, which would be a mixture of one part sulphuret and six parts bisulphuret. Another from Bareges gave 56.375 + 43.625 = one part sulphuret + two parts bisulphuret. Rose found in the beautiful leafy magnetic pyrites from Bodenmais 60.52 + 38.72 (+0.82 alumina) = very nearly a pure sulphuret. Schaffgotsch found in the same ore 60.59 + 39.41. This mixture of two alloys can sometimes be perceived on the very face of the crystals. Berthollet's idea that the iron and sulphur varied their proportions infinitely has not found credence.[3]

Magnetic pyrites occurs in beds along with other minerals containing iron; exists accidentally in rocks and crystallizes in their fissures, sometimes in irregular six-sided prisms, cleaving regularly six-sided; occurs often tabular; color between bronze yellow and copper red, scratching dark greyish black, brittle, with a hardness of 3.5 to 4.5 (5 to 6 of Thompson scratches calcspar and is scratched by feldspar) and a specific gravity of 4.6 to 4.65 (4.631 Thompson), slightly attracted by the magnet, soon tarnishing; its hue, softness and magnetism distinguish it from *iron pyrites* and its paleness from copper pyrites; it becomes red oxyd in the outer flame, fuses and glows in the inner flame to a black globule breaking yellow which is magnetic, whereas nickel and cobalt yield a globule non-magnetic. Dana and Thompson give several analyses varying between 63 50 and 56.37 iron + 36.50 and 43.63 sulphur, and the difference is to be accounted for by the difference in the proportions of the two sulphurets. Boye's analysis of a Pennsylvanian nickeliferous variety of the ore was 41.34 iron + 24.84 sulphur + 4.55 nickel + 1.30 copper.[4]

[3] Karsten, §§ 173, 176.

[4] Dana's System, p. 50; Thompson, i. 441.

Powdered sulphur and iron filings sprinkled with water heat, even to flaming, and mix. forming an undetermined sulphuret and a sulphate of iron. Iron withdraws to itself sulphur from its combination with most other metals and is therefore used in the reduction of galena, sulphuret of silver, cinnabar (zinnober),[5] etc.

The close relationship of iron to sulphur even in the smallest quantities affects in the most important manner the qualities of bar iron, steel and pig metal, converting them to a fusible, brittle, untenacious mass. Hence sulphurous ores must be worked with extreme care and must often be wholly rejected. An almost imperceptible quantity of sulphur in an analysis will make iron red-short, whereas it requires a very measurable quantity of other elements to produce the same effect. The degree of red-shortness is according to the amount of sulphur, and the lowest degrees are not to be dreaded because they are commonly coincident with firmness or tenacity; but the higher degrees make iron every way worthless. The minimum is still unknown, because of the difficulties of the analysis when the percentage of sulphur runs down into the decimal places. Karsten endeavored to obtain the maximum of sulphur in a good forge metal by mixing gypsum with puddling iron, to an analytical proportion of only 0.03375 per cent of sulphur, when the iron was utterly unable to bear the hammer or weld. In a firm and good bar iron which however was called red-short because of its imperfect malleability and its disposition to edge cracks, he found by analysis 0.01 or *one part of sulphur in ten thousand of iron.* Stengel's results are different, for he found 0.03 sulphur in iron not sensibly red-short, and that it required 0.1 to make it worthless. This difference however may have originated in the different determinations of weight of the galena. Karsten's experiments when repeated with great care assured him that the medium bar iron of commerce never contained more than 0.008 per cent sulphur. It is a happy circumstance for metallurgists that the greatest part of the sulphur in ores passes off in the furnace slag on account of the ease with which the union of iron and sulphur is dissolved by lime. Very sulphurous ores afford a pig iron of little value to the refiner; for the remelting of pig iron in cupola or in open fires scarcely diminishes its percentage of sulphur, and rather increases it if coke instead of charcoal be the fuel; and as a rule when iron is

[5] Karsten, §§ 176, 7, 8.

Iron and Sulphur.

refined or grey iron is converted to white with coke in open hearths with a strong blast, the refined iron will be found to contain more sulphur than the grey iron contained at first. It is improbable that so slight a quantity should be a fixed chemical proportion and still more improbable that it should be a union of the little sulphur with the whole mass of iron. Iron long exposed to stone-coal flames imbibes sulphur and becomes red-short, that is, becomes more brittle and fusible, as engine boilers burst in the lapse of time by being weakened from the same cause.[6]

Per- or **Bisulphuret of iron**, or common **iron pyrites** *martial pyrites*, *cubic pyrites*, *mundic*, *marcasite*, *schwefelkies*, *eisenkies*, *fer sulphuré*, is the per- or highest sulphuret known, consisting of 1 weight of iron with 4 weights of sulphur. It is obtained by rubbing the artificial sulphuret with half its weight of sulphur and distilling off the residue in an under brown-red glow heat,—as a dark yellow metallic, voluminous powder, consisting of 45.74 iron + 54.26 sulphur, unattacked by any acids except nitric and nitro-muriatic. With nitric acid it deposits sulphur and becomes sulphate of peroxide of iron. Heated in close vessels to a glow, it sends off sulphur and becomes magnetic pyrites. Heated in air to a glow it becomes pure red peroxide of iron. Berzelius obtained this alloy by heating between 212° F. and a red heat, in a stream of sulphuretted hydrogen, peroxide of iron, hydrated peroxide of iron (artificial or natural in powder or crystal) and spathic iron ore (in powder or crystal). The resulting crystals were perfect pseudomorphs. The bisulphuret is very common in nature either pure or with other sulphurets. It is in fact universally diffused; its home is in clay slate, in beds and crystals; in greenstone and granular limestone it is nodular;[7] in coal-beds and in coal slates it abounds [especially in the lowest beds of the system and in the western States, apparently increasing with its distance west; it takes the form of plants and shells obliterating usually all but the grosser markings, and often being the sole indication of the previous existence of fucoidal vegetation in sandstone, when palæozoic and metamorphosed.] Its pure crystals belong to the sphæroidal system, are metallic yellow and strike fire with steel. The cockscomb pyrites (Kammkies) which differs so curiously and inexplicably from it in easily weathering to vitriol has nevertheless according to Berzelius the same composition, viz.: 45.07 iron + 53.35 sulphur (+ 0.80 alumina + 0.70 manganese).[8]

The bisulphuret of iron cannot be converted into the sulphuret, and still less into regulus iron by heating with hydrogen. Regnault affirms that when watery vapor is directed over the glowing bisulphuret magnetic oxide results with evolution of hydrogen and sulphuretted hydrogen gases. This is in fact the process for obtaining the sulphur of commerce from pyrites. Stromeyer finds that the bisulphuret must be dry distilled at a higher temperature than a full red heat to make the pure or artificial magnetic pyrites; for at merely a full red heat it makes the natural or compound magnetic pyrites, 60 iron + 40 sulphur; and this corresponds with the iron + oxygen compound described as red-heat-crust (glühspan).

[6] Karsten, § 179 to 182. § 183 gives the methods of analyses for sulphur.
[7] Thompson, i. p. 442. [8] Karsten, §§ 174, 175.

Iron pyrites crystals when broken across are often mistaken for silver and for gold, the lustre being splendent metallic whitish or bronze yellow, but the scratch or streak shows brownish black and the mass is brittle, hardness 6 to 6.5, scratching glass and too hard to be cut with a knife and thus distinguished from copper pyrites, silver and gold, specific gravity 4.8 to 5.1, striking fire with steel,[0] giving off sulphur before the blowpipe and leaving a magnetic globule. Sometimes a minute quantity of gold is present. Frequently the pyrites crystals of iron are mixed with those of copper, or lead, or zinc. The great veins or beds of Polk county Tennessee are double sulphurets of copper and iron. It is distinguishable by its yellowish color from silver ores, which are steel grey or nearly black, easily cut and quite fusible; while gold ores are easily cut and hammered out and give no sulphur odor before the blowpipe. Magnificent crystals are obtained in many well-known localities catalogued in Dana's Manual, p. 213.

The **white iron pyrites** or *Marcasite* does not differ in composition from the yellow but crystallizes in secondary forms, is as hard, a little lighter and more liable to decomposition. *Radiated*, *hepatic*, *cockscomb*, *spear*, *cellular* pyrites are only varieties of form.[1] They are called in Europe *Strahlkies*, *Leberkies*, *Kammkies*, *Speerkies*, *Zellkies*, *Spärkies*, *Rhombischer eisenkies*, *Weiss-kupfererz* and *Kyrosite* (when it contains arsenic of copper), *fer aciculaire*, *fer radié*, *fer sulfuré blanc*, etc. *Wasserkies* contains water in combination. *Lonchidite* or *Kausïmkies* is a variety of Marcasite. This *white* bisulphuret is much less abundant than the common pyrites and occurs most commonly in coal-beds, but also in silver, lead and copper veins. Its primary form is a right rhombic prism, but its usual secondary form is one which at first sight seems to have 12 faces, but is really made up of parts of five distinct crystals. It is half a number softer than common pyrites and at least 0.15 less specific gravity although of the same composition.[2]

Iron and sulphuric acid at ordinary temperatures unite only in proportion as the sulphuric acid is diluted with water; but at boiling heat the iron begins to decompose the acid into sulphurous acid and oxygen. Both oxides are dissolved by the concentrated acid at boiling point; the protoxide easiest.

[0] Hence its Greek name from *pur*, fire; Pliny says "it has much fire in it."

[1] Dana's Manual and System, p. 214 and p. 55, 60.

[2] Thompson, i. 443.

Iron and Sulphur.

The diluted acid acts violently at this temperature, evolving sulphuretted hydrogen, and dissolves the protoxide easily, but the peroxide with difficulty. Jones tried to bore and cut hardened steel by means of this active agent, covering it with wax, exposing the line of section, pouring on the acid diluted with six times its weight of water and breaking the bar or plate after half an hour.[3] The salts of both oxides are white, and when dissolved in water are precipitated by concentrated sulphuric acid, the one (protoxide) as granular, and the other (peroxide) as needle-shaped, exceedingly insoluble in water, especially now the protoxide, which before was so soluble.[4] It is the neutral *green vitriol*, 25.43 protoxide iron + 29.01 sulphuric acid + 45.46 water; almost exactly the relation of iron and sulphur in the *magnetic pyrites* (63 + 37). Hence pyrites is the basis of the artificial manufacture of iron or green vitriol. Pure sulphate of the protoxide is dark green blue and covers itself in air with a yellow basic peroxide powder. Dissolved vitriol in free air and especially when heated with nitric acid deposits this peroxide fast. (These changes are important in reasoning on the production of bog ores and rock deposits, and in explaining the colors of rocks which are produced almost all of them by the salts of iron especially the sulphur salts.) Superfluous acid retards the process The double salt deposits emerald green crystals from a mixture of the bluish protoxide salt and yellow peroxide salt. In heating, the vitriol melts, throws off its water of crystallization, then sulphurous acid gas, and precipitates basic sulphate of peroxide, which further heated continues the exhalations and becomes pure red peroxide, *colcothar* or *English red.* The sulphate peroxide brown solution is the vitriolic mother lye, so called, and contains still much sulphate protoxide. The sulphate peroxide of iron is yellowish red, very soluble in water and alcohol, and dries to 39.42 oxide + 60.58 acid. The *basic* sulphate peroxide is yellow, but turns red when its water is driven off by heat; analyzing yellow 62.4 oxide + 15.9 acid + 21.7 water; red 79.61 oxide + 20.39 acid.[5]

A bed of iron pyrites, in the north of Chili, South America, about 15 miles from Copiapo, dividing fusible feldspar rock like fine grained granite, has decomposed (probably) into a bed of **bisulphated peroxide of iron,** white, partly crystalline, partly granular, soluble in water and precipitating in hot water peroxide of iron, and composed of sulphuric acid 43.55, peroxide iron 24.11, water 30.10 (=2 : 2 :: 5), and a little silica, alumina, lime and manganese. The people have dug into this bed for their own use 20 feet deep.[6] The **sulphated peroxide** is generally found incrusting the previous salt, in small grains covered with minute crystals, yellow, translucent, pearly, mixed with sand and containing sulph. acid 39.60, perox. 26.11, water 29.67 (=1 : 1 :: 5), magnesia, alumina, silica, 2.64, 1.95, 1.37.

The shales of the wrought out coal beds of Hurlet and Campsie near Glasgow contained innumerable snow-white needles of *alumina sulphate of iron* an inch long, of some breadth but no sensible thickness, astringent, sweet, soluble, reddening when heated and containing $3\frac{1}{2}$ atoms sulphate of iron + 1 atom sulphate of alumina + 34 atoms water on one analysis, and other proportions of the same on other analyses.[7]

[3] Bulletin de la Soc. d'Encouragement pour l'industrie nationale, Nov. 1837; p. 456 in Karsten.

[4] Karsten, § 220.

[5] Karsten, §§ 220, 221. He treats the action of sulphurous acid on iron shortly in § 222; nitric in § 223; muriatic in § 224; aqua regia in § 225.

[6] Thompson, p. 450.

[7] Thompson, p. 473, i.

How **Carbon and Sulphur** modify each other's influence over **iron** is not well known. Grey iron that contains both dissolves quickly in sulphuric acid and gives out sulph. hydrogen, but white iron slowly, and not until heated. Much sulphur entirely neutralizes the action of carbon, or in other words apparently confounds bar, steel, grey and white iron in plain sulphur-iron without regard to the quantity of carbon they may hold; although it is inadmissible to suppose the carbon made absolutely passive and uncombined with the iron in either the form of graphite or of distributed carbon, at least up to the (at present unknown) point of saturation with sulphur. Scheele shows that graphite and sulphur cannot unite, but that carbon and sulphur can make a carburet. It is not likely that this union is effected in the body of the iron, seeing that although sulphur neutralizes coal in iron, coal cannot neutralize sulphur in iron; and when specular (white) pig metal is melted in a close crucible with sulphur, its carbon comes out in the form of a fine soot over its under surface; a soot having all the qualities of graphite, hard to burn, evaporating without residue under the muffle, but without lustre. Probably this soot is driven off from only that part of the iron which is saturated with sulphur. In another experiment melted grey iron poured upon sulphur separated into sulphur iron above and pure iron below which remained behind, when the sulphur iron was poured off from its surface, as a specular raw iron. The original grey iron held 3.9372 carbon (of which 3.3119 was graphite); the iron poured off held 0.0286 sulphur; and the remaining specular flake iron held 5.4878 carbon (not graphite) and 0.4464 sulphur. It would appear that the iron made sulphur-iron took up a maximum equivalent of carbon, and then the iron not made sulphur-iron took *its* maximum, after which graphite began to form. The greater part of the iron remained behind; but not always as white iron, but occasionally as grey iron, doubtless an accident of high temperature. The extra percentage of carbon in the residue or non-transmuted mass is curious. Grey iron containing 3.8594 carbon (of which 0.5943 was combined carbon, *i. e. not* graphite) smelted and poured over sulphur, and poured off again, left perfect grey iron containing 5.6212 (of which 1.1085 was combined) carbon.[8] Fournet maintains that carbon can re-

[8] Karsten, §§ 192, 193.

Iron and Sulphur.

tort and drive out some sulphur from a saturated sulphur-iron, but Karsten says his sulphur-iron remained for hours with coal at the strongest white heat without change, except taking up some more carbon and becoming soft.[9] When carbonized iron receives sulphur, but too little to neutralize and conceal the presence of the carbon, it grows more fusible thereby; bar iron and steel take a welding heat at a lower temperature than when pure, but do not weld so well, probably because sulphurous iron is too fusible at a white glow. As sulphurous iron becomes fluid at a lower temperature and chills quicker, so red-short iron and steel pass quickly from a white to a red glow, and this obviates the connection of the particles and produces the cold-short quality, which shows itself in a low degree by edge cracking and in a great degree by crumbling under the sledge because of a want of weld. On account of these corner cracks and fissures bar iron and steel which are red-short in the highest degree must also be cold-short. Raw iron shows the influence of sulphur still more strongly because of its quicker and hotter flow and quicker chill, giving the particles still less chance to arrange themselves firmly, which is the secret cause of the weakness of the iron. Sulphur here acts to thin the metal at a lower temperature, and therefore to facilitate chilling; it prevents therefore the formation of graphite (which can only take place at a high and slowly falling heat) and favors the *chemical* connection of the carbon and the iron. Hence the difficulty in getting any but white iron from any sulphurous grey iron or ore, either in the high furnace or in the refinery. Evain of Metz first pressed a hole through red-hot iron with a stick of sulphur, and supposed he had discovered an easy method of making holes through iron instantly and of any required shape, but the action is not quite regular and the result can seldom look workmanlike. The iron must be at a full white heat. At a low red heat the sulphur vapors off without attacking the iron. Steel is more vulnerable than bar iron, because it takes a glow quicker; but no effect at all is produced on pig iron, white or grey, because the carbon cannot be driven off except from fluid or molten iron and therefore the sulphur has

[9] Karsten, § 194, quoting Annales des Mines 3, serie iv. 1,225.

no chance to form a union; and moreover pig iron actually melts before reaching the high white heat necessary for this instantaneous combination with sulphur. A small quantity of sulphur in raw iron thickening its flow when not heated much above melting point makes it porous and vescicular. In a raw iron experimented on (as recounted above) Karsten found but 0.371 sulphur, and yet it made an extraordinarily red-short bar. Coke-pig varied in Karsten's experiments between 0.005 and 0.080 sulphur; and charcoal-pig varied equally, but its whole average was lower, when the same ores were used for making both the coke and the charcoal-pig. The difference of fuel sinks into insignificance in this respect before the difference in the ores.[1]

Iron and Selenium so seldom meet in ores that nothing is known of their relations.[2] They combine as iron 1 (28) + selenium 1 (40=68) when iron filings and selenium are heated together, forming a greyish yellowish hard brittle alloy, losing selenium before the blowpipe, and decomposed by hot hydrochloric acid into protochloride iron + seleniuretted hydrogen.[3]

Iron and Tellurium have unknown relationships.[4]

Iron and Arsenic unite in all proportions making a brittle, hard and fusible alloy. To destroy the magnetism of iron at least an equal portion of arsenic is needful. Bergman's experiment exonerated arsenic in small quantities from the charge of exerting any malign influence over iron; but repeated smelting even with coal dust will not entirely drive off the arsenic. Rinman maintains on the contrary, that a very little arsenic will destroy the forge quality of iron. Hassenfratz found that arseniuretted iron forges pretty well at a red heat but welds badly, giving out strong onion odors and acting more red than cold-short afterwards. Karsten's own experiments showed him that the addition of arsenic gave the puddling an extraordinary rawness, lengthening out the process two or three times, and wasting the iron greatly through the uncommon fluidity and heat of the slag. The iron was considerably harder than common and hammered like steel, but showed itself not in the least red-short,

[1] Karsten, §§ 195, 196, 197. [2] Karsten, § 201. [3] *Pen. Cyc.* [4] Karsten, § 273.

Iron and Arsenic.

and made no scale or corner cracks. But it had lost in tenacity somewhat as subsequent strain tests showed. A very careful analysis showed no trace of arsenic, and gave no explanation of a curiously diminished solubility in aqua regia in the case of this bar iron. Lambadius mentions a rich red iron ore smelted at the Breitenhof works in Saxony to an iron which would not weld in the puddling at all, and was found to contain 3.5 per-cent arsenic. Garnej remarks that some of the Utö ore gives a very cold-short iron, partly owing to arsenic and partly to co-balt. Karsten goes on to say that among the many kinds of pig metal he has had to examine he has never found one holding arsenic. Wöhler on the other hand remarks that arsenic occurs in iron oftener than people suspect, even when made from ores which show no arsenic; that it is easy to overlook in an analysis by not looking for it in the right place, because it does not pass off with the sulphuric acid, nor with the hydrogen, nor in the solution of iron,[5] but remains as an arsenical salt in the black residuum composed of coal, clay, etc., and may be exhibited by caustic potash lye or sulphur-ammonia, and precipitated by acids as sulphur-arsenic, which if again distilled in a glass tube leaves a black residuum of sulphur-molybdenum. In this he had found arsenic in four specimens of pig metal from as many different iron works. Berthier analyzed Algerian bombs and balls supposed to have been cast in Spain and found them to contain 9.8 per cent arsenic and 1.5 carbon. The iron of the bombs was brilliant and showed white grey specular flakes, very brittle, easily pulverized and as heavy specifically as 7.585. That of the balls was even greater, 7.65, contained 27 per cent Arsenic, and was full of holes. Both kinds oxidized rapidly in air when moistened, and the oxide dissolved in nitric acid preci-pitated carbon and arseniuret of iron, retaining itself no trace of the same, showing that no arseniate of the oxide of iron had been formed. Karsten smelted together 95 parts cement-steel with 5 parts arsenic-metal (32 arsenic + 68 iron) making the arsenic 1.6 per cent (the reactions due to the carbon being considered). The steel melted quickly, looked homogeneous, was very soft,

[5] That is when heated; but if the dissolution is carefully made *cold*, and the filtered solution alone heated the arsenic will be found in the white precipitate of arseniate of the oxide of iron.

and could not be much hardened by tempering, acted like mellow raw bar iron, had a blue green color and seemed to have entirely lost its toughness and ductility. Bar iron 75 and the same arsenic metal 25, mixed, melted quickly to a soft light fusible unmalleable dark grey alloy containing 8 per cent arsenic. It follows that arsenic lessens materially the tenacity of iron, makes it softer, and as little as 1.6 per cent destroys its ductility and malleability, and therefore what has been said above at the beginning of this paragraph does not make it quite certain that even very small amounts of arsenic may not make iron cold-short.[6]

The **hydrous diarseniate of iron,** *white iron sinter*, found near Freiburg is a yellowish grey, kidney ore, soft, friable, coarse earthy, adhering to the tongue, dull, rough, containing 40.45 peroxide iron, 30.25 arsenic acid, 28.50 water, with traces of sulphuric acid, $=2+1+6$ atoms.[7]

The **hydrous subsesqui-arseniate of iron,** cube iron ore, *hexahedral liricone malachite*, *wurfelerz*, *pharmacosiderite*, *fer arseniaté*, occurs in copper veins in primary rocks, in great abundance in Cornwall, frequent elsewhere, always in olive green (sometimes grass and emerald green, yellowish brown and yellowish red) crystals, of cubic primary form, adamantine lustre, translucent edges, rather sectile, hardness 2.5, specific gravity 3.000, growing red in a gentle heat, intumescing when hot to a red powder, emitting fumes before the blowpipe and melting to a magnetic scoria; contains 39.20 peroxide iron, 37.82 arsenic acid, 18.61 water, (2.53 phosphoric acid, 1.76 insoluble, 0.65 copper,) $=1+1+3.5$ atoms.[8]

Dana gives a somewhat different analysis from Thompson, to wit, 28.1+12.6 per+protoxide iron, 40.4 arsenic acid, 18.9 water. *Brudantite* is perhaps a very impure sulphurous variety of cube ore.[9]

Arseniosiderite, *Arsenocrocite*, nearly of this composition (40.52+39.37) but contains less water (8.23) and moreover *lime* (11.88), occurs as fibrous golden yellowish brown concretions in a manganese bed at Romanêche in France.[1]

Scorodite[2] found first in the Tin-croft mine in Cornwall and afterwards in primary rocks in Saxony and in Brazil, is a whitish or sky blue, leek green or brownish vitreous, translucent, brittle crystal of 36.25 protoxide iron + 31.4 arsenious acid + 18 water, with protoxide manganese, lime, magnesia and sulphuric acid, therefore = 4 atoms subsesqui-arsenite iron + 1 atom subsesqui-arsenite manganese, etc.[3]

Hydrated arseniate of iron, 24.5 peroxide iron, 50.00 arsenic acid, 16.00 water $(=1+1+2$ atoms), occurs in the cellules of a silicious perhydrate of iron at Antonio Pareira, Villa Rica, Brazil, as a pale porous mass, powdering white.[4]

The **sesqui-arseniate of iron,** *leucopyrite*, *glanzarsenic kies*, *arseneisen*, *arsenikeisen*, *arsenicalkies*, *arsenosiderit*, *lölingite*, *mohsine*, 27.2 iron, 72.8 arsenic, $(=1+1.5,)$ contains sometimes as much as 2.20 sulphur; one specimen reads 13.50+60.40+5.20 sulphur + 13.37 nickel + 5.10 cobalt. Mohs determined it as Oxotomon's arsenical pyrites. Hitherto it has only been found with sparry iron ore or

[6] Karsten, §§ 268, 269.
[7] Thompson, i. 457.
[8] Thompson, i. 457.
[9] Dana, ii. 423.
[1] Dana, ii. 422.
[2] From σκοροδον garlic.
[3] Thompson, i. 476; Dana, ii. 419.
[4] Thompson, i. 458.

Iron and Antimony.

imbedded in serpentine, of which Hoffman's specimen had 2.17. It is a silver white or steel grey opaque brittle octahedron, hardness 5 to 5.5, specific gravity 7.228.[5] Metallic arsenic sublimes in a glass tube; on charcoal, fumes and makes a magnetic globule; dissolves in nitric acid. A crystal weighing two or three ounces is said to have been found in Bedford county Pennsylvania, and a mass of two pounds in Randolph county North Carolina.[6]

Iron, Arsenic and Sulphur form *arsenical pyrites*, **mispickel** or *prismatischer arsenikkies*, *fer arsenical*, *danaite*, *plinian*, *arsenopyrite*, *marcasite*, in the proportion 34.4 + 46.0 + 19.6 (=1+1+1 atoms). In some specimens **cobalt** is present to the extent of 9.00. It is found commonly in beds and veins in crystalline or metamorphic rocks, with silver, lead and tin, iron and copper pyrites and blende, and in serpentine. Dr. Genth has lately discovered it to be among the richest of all gold ores in South Carolina. It occurs in veins at Freiburg and Munzig Germany, Funaberg Sweden, in Cornwall, and elsewhere; in fine silver-white or steel-grey metallic brittle crystals at Franconia New Hampshire and many other places through New England, New Jersey and eastern Pennsylvania.

Glaucodot contains much sulphur and cobalt.[7] Before the blow-pipe it gives off copious arsenical vapors and the crystal becomes magnetic.

The double salt *sulpharseniate of iron*, *eisensinter*, *pittizite*, *pitchy iron ore* (Thompson) was first described by Karsten and analyzed by Klaproth. Stromeyer thought it decomposed mispickel because they abounded together in Saxony. It is a grey or black-brown mass or incrustation, streak lemon yellow, fracture flat conchoidal or fine grained, resinous, shining translucent at the edges, scratched by the knife, brittle, specific gravity 2.40 and composed of 33.10 peroxide iron + 26.10 arsenic acid + 10.00 sulphuric acid + 29.20 water and a little sesquioxide of manganese; or $1\frac{3}{4}$ atoms arsen. perox. + 1 subsesquisulphated perox. + $12\frac{1}{2}$ water.[8]

Arsenical iron in a bed form, one to four inches wide and at least 328 feet in length occurs in granite and mica slate in Jackson county New Hampshire and where this bed is cut by a trap dyke Dr. C. T. Jackson's celebrated tin crystals with copper pyrites, tinged with tungstate of manganese and iron was discovered. The copper pyrites is a bisulphuret of copper and iron. Iron pyrites is disseminated through the rock and oxide of iron occurs. Daubrée supposed the oxide tin in all veins to have come from the interior of the earth as a gaseous fluoride, and speaks of the volcanic exhalation of chloride of iron lining the fissures and caverns of lava currents with specular oxide of iron; the chloride of iron being converted by steam into chlorohydric acid and this oxide.[9]

Iron and Antimony mix in all proportions to make a hard, brittle white alloy, the iron gaining fusibility and the antimony hardness. Karsten experimented at the Creuzberg works in

[5] Thompson, i. 443. [6] Dana, ii. 62. [7] Dana, ii. 63.
[8] Thompson, i. 478. [9] Trans. Ass. Amer. Geol. and Nat. 1840–1842, p. 316.

Upper Silesia with 1 per cent of antimony, which was found to exert a much more injurious influence on pig metal in the puddling furnace than so much tin. Under the weld-heat the same tin smell was perceptible, but the bar iron was far brittler, breaking with the greatest ease not only when cold but also when hot. Hassenfratz's experiments with *spiesglanz* (antimony ore) showed in like manner that it made iron very hard to forge, and both red- and cold-short when forged, with only a percentage of 0.23. Karsten received a specimen of cold-short bar iron supposed by the sender to be spoiled by arsenic, but on analysis he found besides an inconsiderable amount of sulphur and 0.38 per cent. of phosphorus, which could not have been sufficient to make it very cold-short, 0.114 per cent of antimony which explained the whole. Happily for iron manufacturers antimonial ores of iron are very rare. When they cannot be handpicked they make irrecoverably cold-short iron.[1]

Berthierite, *Haidengenite* (of Berthier) was worked in veins near Chazelle in Auvergne but abandoned on account of the badness of the antimony made from it. It is an iron black mass, covered with iridescent spots, confusedly foliated, much mixed up with quartz, carbonate of lime and iron pyrites, sometimes showing rudimentary prismatic crystals unlike the sesquisulphide of antimony, fusing readily before the blow-pipe and yielding 14.9 iron + 48.3 antimony + 28.3 sulphur + 3.2 iron pyrites + 3.2 quartz + 0.3 zinc, or 1½ atom sesquisulphide antimony + 1 atom sulphuret of iron. Berthier has since pointed out two more such compounds, one containing 6.3 and the other 18.0 sulphuret iron.[2]

Iron and Chrome once mixed by Hassenfratz made a metal that forged well, but was a little red-short. Chromiferous iron ores are uncommon, but chrome is quite as often found in pig iron as titanium is, but is entirely eliminated by puddling. Vauquelin gives an analysis of a red-short iron showing 0.6 per cent phosphorus and 0.4 per cent chrome. *Steel and Chrome* form alloys better known, by Berthier's, and by Stodart and Faraday's experiments. Berthier tried first 1 per cent and then 1½ chrome with cast steel, and produced a perfectly good and very beautiful damasked steel. Stodart and Faraday got admirable steel with 1600 steel and 16 chrome, and also 48 chrome. The last alloy, 3 per cent chrome, was harder but forged excellently well.[3]

Chromiron ore, *Chromate of iron*, first discovered at Var in nodules of serpentine, occurs in the Ural, the Shetland islands and near Baltimore and other places

[1] Karsten, § 267. [2] Thompson, i. 499. [3] Karsten, § 277.

Iron and Titanium.

in the United States. It is iron or brown-black, streak brown, massive or octahedral, imperfectly metallic, uneven, subconchoidal, brittle, 5.5 hard, 4.321 specific gravity, not attracted when pure, and when pure crystals are analyzed, giving, 29.24 peroxide iron, 52.95 green oxide of chromium, 12.22 alumina, 3.09 white matter, 0.70 water and a trace of silica; or 1+2+1+etc, atoms.[4]

Volkonskoite, a grass-green compact conchoidal dull very soft smooth mineral occurs in veins and nests, contains 1 atom of chromate of iron, or 7.2 per cent of the peroxide.[5]

Iron and Molybdenum have relationships unknown to Karsten.[6] In mineralogy *molybdine* or *molybdena ochre* produced from *molybdenite* or the sulphuret of molybdena unites with the peroxide of iron and has been so found in California. (D. D. Owen in Dana, ii. 144.)

Iron receives **Tungsten** in its form of Wolfram or oxide of iron and manganese without injury; and Hassenfratz found Tungsten itself only made bar iron a little red-short. Cold, it was uncommonly extensible and like steel took a white face in hardening and showed in forging out a more granular and stringy structure, so that Sheel (tungstate of lime) or a minute portion of wolfram will merely harden iron.[7] Wolfram is a common ore in tin mines and is said to accompany lead in graywacke. It is massive and also crystalline, greyish black, foliated, imperfectly metallic opaque, not very brittle, 5 hard, (7.155), melting with borax to a green bead, and containing variable proportions of tungstate of iron and tungstate of manganese.[8] It is called also *Scheelate* of iron and manganese, but Sheelite is properly its name when lime replaces the iron.[9]

Iron and Columbium or **Tantalum** occurs as *Columbite* or *Tantalite* detected again by Dr. Torrey at Haddam, Connecticut, and found in Finland and Bavaria, as iron black crystals tinged blue, 5.25 hard, 7.2 to 7.9 specific gravity, infusible, and consisting of from 1 to 8 atoms of columbate of iron + 1 atom of columbate of manganese; that is, containing variously 14. protoxide, 14. peroxide, 7. protoxide iron.[1] Dana says it is essentially protoxide iron and manganese with columbic acid, and gives many localities. He makes *Tantalite*, *cassiterotantal*, *siderotantal*, etc. another crystal.[2]

Iron and Titanium occur together in so many ores that their relations are important. Karsten says that titanium makes the Norwegian iron *strengflüssig*, hard to smelt, so that when the titanium is abundant in the ore the 35 foot charcoal stacks of Arendale cannot smelt it, and it is therefore hand-picked. Otherwise no injury is done the iron which in fact is harder, firmer and can stand more wear. Hassenfratz experimented with *rutile* or *red schörl* (oxide of titanium) and found his iron remain malleable and neither red- nor cold-short. It is doubtful if the metals unite chemically. Titanium as *sphen* frequently

[4] Thompson, i. 482. [6] § 273. [8] Thompson, i. 487. [1] Thompson, i. 485.
[5] Thompson, i. 495. [7] Karsten, § 277. [9] Dana. [2] ii. 351.

occurs in the nodular iron ores (sphærosiderites) of the Coal Measures but never in the analysis of the iron made from them, passing off in fact with the slag or lying as separated crystals in the pig metal; and this happens because Titanium requires a higher heat than iron to reduce from its oxide with coal, and a still higher temperature to smelt afterwards. Wollaston first discovered its beautiful coppered and little dice-like crystals in the furnace-stack; and since then they have been found in many furnace-stacks, and the metal in red grains in many varieties of pig iron, or invisibly but mechanically mixed with pig iron in small quantities disappearing from it in the puddling. The traces of titanium are met in much of the ordinary pig iron of commerce. Karsten found that **with titanic acid** in varying proportions specular peroxide of iron is frequently mixed and called *ilmenite*, *titanic* or *titaniferous iron* ore or *subsesquititaniate* of iron, wholly useless as an ore, as the titanic acid is in excess. But *titaniate* of iron (*gregorite* or *menachanite*) *iserine*, *crightonite* and *nigrin*[3] are crystalline alloys of titanic acid with the protoxide of iron.[4] This sesquititaniate of the peroxide exists in such extraordinary abundance in Brazil according to M. Montlevade, as to constitute mountain beds of great thickness and lateral extent, alternating with transition (or palæozoic) rocks.[5] Analyzed by Berthier its constituents appeared to be 56.2 peroxide iron, 41.0 Titanic acid, 2.5 quartz, Ox. Mang. a trace; evidently 1.5+1 atom. Its color is grey, and its mass falls into rhomboid fragments, with an almost compact fracture of fine grains a little scaly, little or no lustre (which distinguishes it from specular iron ore), full of fissures filled with pellicles or reddish-brown mica and cut by veins of quartz.

Titaniferous iron in thin plates or seams in quartz, in grains and sometimes in large tabular crystals, occurring near specular iron, characterizes the Lower Silurian metamorphosed belt of rocks running through New Jersey and Vermont into Canada. It occurs in Connecticut and Rhode Island,[6] and in the azoic serpentine and chromic iron belt on the Maryland State line, and in the South.

It was first observed at Arendal in Norway. It is an iron grey, frequently

[3] *Hystatite* includes Sheppard's *Washingtonite*.—DANA.
[4] See Thompson for their composition.
[5] Annal. des Mines, v. 479 in Thompson, ii. 467.
[6] Dana.

whitish, massive, crystalline ore with a black streak, primarily a rhomboid; foliated, conchoidal fracture, opaque, brittle; hardness 5 to 5.5, specific gravity 4.49 to 4.79, sometimes magnetic, the Brazilian is polar; rounds its thin edges but does not fuse before the blow-pipe, and shows a mean of three analyses 55.58 peroxide iron, 17.76 protoxide iron, 22.73 titanic acid $=3+1+1$ atoms, or 3 atoms of *tetra*titaniated *per*oxide + 1 atom *tetra*titaniated *prot*oxide. A mean of four other analyses gives $26.1+28.5+40.9$ $=5+7+6$ atoms, or 5 atoms of *di*titaniated *per*oxide + 6 atoms of *di*titaniated *proto*xide. A last analysis seems to show 5 atoms peroxide + 1 atom titanic acid. Three distinct species at least exist and there may be many more. It is probably a double salt; to which class *Ilmenite* must also be referred after the full analysis of Mosander and Rose.[7]

Iron and Potassium.

Ilmenite, an ore near Minsk, Russia, brownish black, crystallized in the anhydrous peroxide form, translucent, brittle, slightly magnetic, H. 5.75, Sp. Gr. 4.766–4.808, contains 11.2 peroxide iron, 36.6 protoxide iron, 46.8 titanic acid with a little manganese.[8]

Steel and Titanium, 199 : 1, behaves like the best steel, but analysis showed that the titanium was distributed very irregularly through the mass and therefore not chemically but mechanically. It was beautifully damasked when polished. Karsten made the interesting discovery that the dark blue hue of furnace slag is due to a protoxide of titanium.[9]

Iron and Vanadium, a metal discovered by Sefström in certain Swedish irons easily oxidized, combined in such a way as to do no injury apparently to the iron; and at any rate vanadium is exceedingly rare.[1]

Iron and Ammonia (Nitrogen + Hydrogen, an alkaline compound gas) have little affinity. Savart found that iron wire subjected red hot for nine hours to a stream of ammonia increased in weight one 670th and fell in specific gravity from 7.788 to 7.6637. After one or two hours the iron became brittle with a fine steel fracture and could be tempered to strike fire with flint. After eight or nine hours it could not be tempered but became softer than common iron and showed a blackish grey flaky fracture. Despretz found its absolute weight at this time increased from 5 to 11 per cent, without any oxidation; it was white, brittle, even friable, less affected by air and water, but equally soluble in acids and magnetic. Despretz thinks all this due to a union of **iron and nitrogen.** In fact he subsequently succeeded in combining iron directly with perfectly dry nitrogen.[2]

Iron and Potassium as carbonates are found mixed in the clay iron-stone ores; but pure iron and the iron oxides are unaffected by the fixed alkalies when digested with them. Iron at a glow heat decomposes **potassa** and **soda**, producing potassium and sodium, and oxidizing itself. Pig metal melted with the alkalies is changed

[7] Thompson, i. 490.

[8] Thompson, i. 488. Dana calls it *Crichtonite*, *Menaken*, *Menaccanite*, *Kibdelophan*, *Basanomelan*, *Hystatite*, *Washingtonite*, *Mohsite* (ii. 115), all double salts; fine specimens are to be obtained in Orange county New York and elsewhere in the United States. Rose's *Mengite* contains Zircon.

[9] Karsten, § 275. [1] Karsten, § 273. [2] Karsten, § 151.

to steel iron and at last to pure bar iron, by the disappearance of its carbon in the reduction of the alkalies; but no union can be shown to take place between the metals; not even when hydrated alkalies and iron are melted in a close crucible. Hassenfratz's investigations show how little influence the alkaline metals have over the formation of bar iron [and the practical working of the alkali-charged carbonate ores shows the same thing]. A gun barrel through which a great quantity of potassium had been obtained, was found to be as malleable as before it was put to this service, soft and neither red- nor cold-short. Charcoal always contains potassa but no trace of potassium has ever been found in charcoal iron.[3] Iron and potassium were combined by Serullas (as he asserts) smelting iron filings, tartar (weinstein) and lampblack (kiehnruss), and making the iron brittle; but it must have been converted into wild steel or raw iron. Charcoal iron never contains potassium, nor has Karsten ever found potassa in blast furnace slag, although it occurs in coal ashes in considerable quantities. The potassa is therefore probably reduced to potassium in the stack, volatilized and returned to potassa again in the free air. Part of it is found as carbonate, muriate and sulphate of potassa mixed with a crowd of other substances and attached to the inwalls, or under the tymp, where Berthier found large quantities of potassa. In the refining hearth however *potassium and sodium* may unite with raw iron, when potash is employed to cure the raw iron of phosphorus. Karsten tried to observe this union carefully by mixing quantities of 5 to 6 per cent of potash and of carbonate of soda with the iron during the whole time of refining the iron. But the result was a disappointment. The iron not only lost in welding quality but in tenacity, although but slight traces of the alkali could be found afterwards in it. This looks as if a minute quantity of these alkaline base metals would ruin iron when forced into union with it; but the conclusion is of no importance to iron manufacturers as such feeding of iron with potassa and soda is never called for.[4]

Iron and Lithium—Barium—Strontium are unions unknown or uninvestigated.

Iron and **Calcium (lime** metal) unite, as iron and the alkaline metals do (potassium, sodium, etc.), by the decomposition of lime (calcia) at a very high heat, but unite imperfectly. Mushet has experimented on the influence of lime on iron melted together in crucibles and found it made iron much more brittle and especially red-short. Caustic lime robs molten pig metal of its carbon. Pure Carrara marble added to iron in the refinery does not lessen but rather heighten the tenacity of the bar; but as no trace of the lime could be found by analysis in the bar, the explanation must be that the marble cleansed the iron of some of its phosphorus. When large quantities of carbonate of lime were continually added to iron in the refinery process, the tenacity of the bar iron was really lowered; it welded worse and spalled

[3] Hassenfratz im Journal des mines, t. xxiii. (Nr. 136) p. 275, in Karsten, § 233.
[4] Karsten, §§ 233, 234.

Iron and Aluminium.

under the hammer; it was neither cold- nor red-short, but lacked the welding property and therefore a firm consistency; was technically *ragged* (hadriges) iron; one such specimen gave 0.245 lime = 0.177 calcium, a quantity large enough to ruin any bar iron. Some ores require a surplus of lime flux, and their pig metal occasionally yields traces of lime, but not often.[5]

Iron meeting **Lime** or **Magnesia** in water is hindered from rusting by them as by the fixed alkalies; meeting them dry with coal dust at a melting heat it deoxidizes them to metals. Iron unassisted by carbon seems to have little power over the hydrated earths. Raw iron loses most of its carbon when smelted with earths, and is therefore refined.

Iron and Magnesium. Karsten never found traces of this metal in any bar iron and in a few instances only in pig iron, and thinks the metallurgist need give himself no uneasiness about it.[6] But the care with which most iron founders select blue limestone from white, with the desire to avoid magnesian layers shows the need of a thorough discussion of the influence of magnesia. The presence of the sulphate of barytes in many rocks makes it desirable to know the part that **Barium** plays in its unions with iron.

Iron and Aluminium (**clay** metal) were found united by Stodart and Faraday in the best Indian Steel or Wootz, and hence, it was conjectured, its admirable qualities. The artificial alloy justified the conjecture. Three experiments of Karsten on a large scale with clay in the refinery showed that the refining process was retarded by the abundant production of protoxide silicates, but no *evident* injury to the tenacity of the bar iron resulted, and on analysis of the bar iron scarcely a trace of alumina appeared, although the analysis was conducted so as to insure the exhibition of all there might be present. Nor was he ever able to find more than a trace of alumina in any of the various kinds of pig, bar iron and steel that he analyzed; therefore he doubted the reduction of alumina to aluminum in the high-stack smelting process, and even the possibility of effecting such an alloy by direct smelting of clay, iron and coal in crucibles. On the other hand, if in the common puddling process any aluminum be taken up it must greatly diminish the tenacity of the bar, because the strongest traces of alumina are found in rotten (faulbrüchigen) iron. Faraday found in one steel 0.024 and in another 1.3 alumina, and very various percentages in wootz, but Karsten considers some of the phenomena developed

[5] Karsten, § 242. [6] § 242.

by Faraday in these analyses anomalous. His own assay of a genuine specimen of wootz gave very different results; it dissolved almost entirely away in aquaregia and left but a trace of alumina behind. Tartaric acid threw down iron and 0.1 manganese. The 0.54 burnt white ash contained phosphoric acid, silica, titanic oxide and doubtful traces of alumina. It remains therefore highly problematical, with the probability in fact against it, that small quantities of aluminium give its excellence to wootz. It is indeed true as Stodart and Faraday remark that steel and bar iron differ in their modes of acceptance of small quantities of metals; which need not be injurious to steel even when they very much lower the tenacity of bar; and this may be true of aluminium. Stodart and Faraday give the following prescription for making aluminous steel: Fine-broken pure steel or good bar, mixed with charcoal dust and long and strongly heated, makes a dark metal-grey alloy like tellurium ore (Blättererz) of a highly crystalline aspect, the crystal flakes often $\frac{1}{8}$ inch broad setting through the ingot, and very homogeneously and regularly composed of 94.36 iron + 5.64 carbon. Pulverized and mixed with pure clay and long and strongly heated in a close crucible, this first alloy forms second alloy, whitish, brittle, granular and containing 6.4 alumina; 40 parts of which smelted with 700 parts good steel make an admirable malleable damasked wootz-like steel; also 67 parts with 500 of steel gave a very good malleable and beautifully damasked steel with all the characteristic excellences of Bombay wootz.[7] Karsten reiterates his disbelief that wootz owes any of its virtues to aluminium and his assurance that if the latter reach 1.00 in any sort of iron or steel we may be well convinced of its injurious effect, inasmuch as he never found by his method of analysis even traces of alumina in but a few of the many specimens he analyzed. His method was the common and sufficient one to dissolve the iron in aquaregia; to dry; to moisten with muriatic acid; redissolve in water; filter; precipitate with caustic salammoniac; dissolve the precipitate in a minute quantity of muriatic acid and boil long in a wide porcelain dish with concentrated caustic potassa lye, so that all the oxide of iron is thrown down and an excess of potassa remains. Dilute with

[7] Karsten, § 240, quoting S. and Faraday in Archiv. u. s. f. ix. 322 u. f.

abundance of water, filter, sweeten, over saturate with muriatic acid and decompose with carbonate of ammonia.[8]

Iron and Manganese.

Crucite is a crystal 2 atoms of terferrate of alumina (according to Thompson) +1 atom of terferrate of lime, to wit, 81.67 peroxide iron, 6.87 alumina, 6.00 silica, 4.00 lime, 0.53 magnesia; found at Clonmell, Ireland; color red outside, metallic black within; always crystalline, four sided oblique prism. Its specific gravity 3.58 to 3.81 distinguishes it greatly from specular iron, next after which Thompson places it.[9] Dana's *Crucite* is quite another thing, to wit, Andalusite, an accidentally ferruginous silicate of alumina.[1]

Iron and Glucinum,
Iron and Yttrium,
Iron and Cerium,
Iron and Zirconium,
Iron and Thorium,
uninvestigated.

Iron and Manganese almost always go together. When manganese is in small proportion to the iron it gives it hardness without disturbing its malleability and mellowness. Karsten has found as much as 1.85 per cent manganese in bar iron which was quite faultless. The metals melting at about the same high temperature, no trials to alloy them have been made. Mushet's experiments seemed to show that 40 parts manganese was the highest quantity 100 parts of iron would take up, making an alloy of 71.4 pig iron + 28.6 manganese, no longer attracted by the magnet, and more or less brittle according to the amount of carbon introduced. The action of manganese on iron was still therefore a desideratum. Rinman mentions in his history of iron a manganesian pig metal made by certain Swedish furnaces which possessed the unheard of and incredible property of attracting the magnet only when red hot. Although it may very well be that the greater or less hardness of iron may depend on its containing manganese or not, certainly its malleability or brittleness is independent of any such influence, and dependent upon its Carbon, Silicium, Sulphur or Phosphorus. Bar iron may contain as much manganese as steel, and there is steel that shows no trace of it; on the other hand much bar iron contains it. Manganesian iron and steel will be harder than iron and steel that contain none. Bar iron cannot be

[8] Karsten, § 241. [9] Vol. i. p. 436. [1] System, 1854, vol. ii. 258.

made steel-hard with manganese, but always with carbon. Yet there are metallurgists who insist that steel *must* contain manganese and that bar iron *cannot* contain as much as is found in steel. They have gone even so far as to assert that it depends entirely on the more or less complete elimination of manganese from puddled pig iron whether the result of the process shall be bar iron or steel. It is the carbon that hardens steel; yet manganese may indeed add to this hardness. I have frequently found bar iron (continues Karsten) with a much greater proportion of manganese than the best worked raw steel, and it is well known that not a trace of manganese can be detected in the cast-steel which is precisely that most sought after in the market. The best Steyermark and the best Siegen raw steel contain no manganese, although made from pig metal containing several per cent. It is universal experience that manganesian iron ores are apt to make steel, a fact inducing many to confound these ores with steel ores. Even if it could be proved that the greater proportion of manganese in these ores was the cause of their producing pig metal better adapted to making steel, it would still remain certain that it is not the manganese but the conditions for the union of iron and carbon which the manganese supplied (and in a very different way from itself uniting with the iron) that causes white pig metal to make steel more readily than grey. White pig metal made from ore containing little or no manganese makes steel as readily as, and because it receives carbon in the same way as white pig metal made from high manganesian ores; so experience expressly teaches. It is however the rule, for other reasons, that pig metal made from manganesian iron ores is purer than white pig metal made from most of the non-manganesian iron ores. But white iron made artificially from grey iron takes carbon in the same way and makes as good steel as any other. The high manganesian iron ores moreover are so apt to give white, hard, brittle metal, that the opinion comes to prevail that grey metal can hardly be blown from them at all, and that it is the manganese that hinders graphite from forming. The most perfect white iron called looking-glass iron (spiegel eisen, spiegel flosz, rohstahleisen, rohstahlflosz) can be *steadily* produced from almost no ores but these, which has led German iron-makers to think the manganese not only influenced the union of carbon and iron, but gave

the silver look to this kind of iron. But later researches prove that it neither hinders the formation of graphite, nor whitens the iron, effects due entirely to the temperature within the stack; but that it favors the production of white iron by forming with the silex in the burden a very fusible silicate. From the very same ores have been blown grey iron holding much manganese and the whitest iron holding little. In fact in spite of the fluid silicate of manganese slag, grey iron is sure to be made so soon as the heat of the stack gets up high, or a basis of union is afforded for an infusible silicate.[2]

Iron and Manganese.

The relations of Iron and Manganese are as intimate and peculiar as those of Nickel and Cobalt; of Chlorine, Iodine and Bromine; of Sulphur, Selenium and Tellurium; of Calcium, Strontium and Barium; of Lithium Sodium, and Barium, etc. What the essential, ultimate cause of such resemblances and relationships can be Dumas and Faraday may speculate upon and future chemists may perhaps discover; but their practical effects are evident and may be turned to use. The elements of matter cannot throw themselves into such triads without a meaning. The dreams of the Alchemists may yet be realized in a way they did not dream of. They were wise enough to anticipate us in the instinctive conjecture that the essence of matter under all its multiforms is yet but one; and their natural inference was that by properly mixing gold and lead some intermediate metal would result; therefore that by finding some higher form of metallic matter than gold and mixing it properly with some lower form as copper or silver, gold would be the product. Dumas has shown for the first time by the tables of chemical equivalents prepared by the common labor of all chemists, the probability, in fact the almost certainty, that nature is producing by such mixtures such intermediate metallic elements. Take this first triad for example:

Chlorine, a gas, yellow, with an equivalent	36
Bromine, a fluid, red, " "	78
Iodine, a solid, purple, " "	126

three elements which hunt through nature in one leash, pursue the same game, and obey the same words of command, replace each other in all their salts, stand in the same order to one another in combining affinities, in elasticity, in odor, and in the power to bleach; and the chemical equivalent of Bromine 78 is nearly the exact mean of the equivalents of Chlorine on its right hand with Iodine on its left, 36 + 126 = 162. In the case of the other triads the mean equivalent is exact:

Potassium	40		Calcium	20		Sulphur	16	
Sodium		24	Strontium . .		44	Selenium . . .		40
Lithium	7		Barium	69		Tellurium . .	64	

It is known that Oxygen has another form Ozone; that Sulphur has another form black and elastic like India rubber; that Phosphorus has another form Red phosphorus uncombustible and innocent; that Carbon has two forms as Coal and Diamond; that even Alumina has two forms one soluble and the other insoluble in sulphuric acid, the difference being practically recognized in the preparation of the

[2] Karsten, §§ 280, 281, 282.

sulphate from clay, but not understood.[3] It remains to be seen therefore whether Iron and Manganese be not perhaps allotropic or identical. *See end of chapter.*

The *manganesian iron ore* of Stirling Massachusetts gave to Thompson's analysis 75.50 peroxide iron, 22.65 sesquioxide manganese (3 : 1), with 1.15 titanic acid and iron. It is a black, semi-metallic, red streak, foliated, smooth, brittle, opaque ore showing some splendent facets as of octahedral crystallization, hardness 7, specific gravity 5.08, fracturing small conchoidal, looking like cherry coal and acting feebly on the needle.[4]

The *Franklinite* of Sussex county New Jersey, commonly called a *zinc ore*, but equally a manganesian ore inasmuch as it is composed of 4 atoms peroxide iron + 1 atom sesquioxide manganese + 1 atom oxide of zinc; or of 1 atom biferrate manganese + 1 atom biferrate of zinc, was analyzed and described by Berthier in 1819,[5] as an iron-grey granular and massive ore, powdering dark brown with a fracture conchoidal, and also as octahedral crystals sometimes several inches long, semi-transparent, blood red, brittle, hard (6 to 6.5), specific gravity 5.07 (Berthier says 4.87; pieces with red zinc 4.25), acts sensibly on the needle but is not polar, and consists of 66 peroxide iron, 16 sesquioxide manganese, 17 oxide zinc.[6] Abich gives 68.88 + 18.17 + 10.81 and Dickerson 66.12 + 21.50,[7] so that the proportion of manganese and zinc is far from being settled in this famous ore. See more under *iron and zinc.*

The *sesquisilicate of manganese* found in Franklin New Jersey described in the Annals of the New York Lyceum contains 6.76 protoxide iron, or 1 atom of the tersilicate of iron with 8 atoms of the sesquisilicate of manganese. Thompson also gives a *red mangankiesel* with 13.50 protoxide of iron while another specimen has but a trace of iron. In fact all the manganesian ores and minerals contain more or less iron and all the iron ores more or less manganese.[8]

The *ferruginous silicate of manganese* found at Sparta New Jersey, a slightly reddish brown six-sided prism, foliated, glimmering, opaque, brittle crystal contains 15.45 peroxide iron, 46.21 protoxide manganese, 30.65 silica, 7.30 water and carbonic acid, = 1 tersil. iron + 3 sil. mang. + 2 water.

Newkirkite is one of many species long confounded under the name of "grey ore of manganese;" brilliant black, metallic splendent; in microscopic right rectangular needle prisms coating, red hematite and analyzing 40.35 peroxide iron + 56.30 binoxide manganese + 6.70 water, by a very complicated atomic arrangement.[9]

Huraulite, a reddish yellow small transparent, vitreous crystal contains 11.52 protoxide iron, 33.30 protoxide manganese, 38.00 phosphoric acid, 18.00 water, = 2 atoms diphosphate iron + 6 atoms phosphate manganese + 13 atoms of water.[1]

Helvine is a sulphuret and silicate of manganese containing 5.5 of protox. iron.

Iron and Nickel will be noticed together under the head of meteoric iron in the chapter on ores. If chemically compounded they unite in various proportions; for six specimens in Thompson show 1.5+98.5, 3.5+96.5, 6.36+91.76, 7.87+90.76, 8.21+91.23 and 8.59+91.51, which last is just 1 atom (3.25) nickel + 10 atoms (35) iron. Bergman's experiments

[3] W. M. Uhler of Phil.
[4] Thompson, i. 437.
[5] Annales des Mines, iv. 483.
[6] Thompson, i. 438.
[7] Dana, ii. 106.
[8] Thompson, i. 520.
[9] Thompson, i. 510.
[1] Thompson, i. 518.

Iron and Nickel.

show them uniting in various proportions to make a mellow, ductile alloy. The magnetic powers of nickel being once discovered, the discovery of those of all the metals in their order followed.[2] Nickel alloyed with cast iron is now believed to increase its brittleness, as carbon, phosphorus or sulphur does. Fairbairn's experiments, published in a paper read before the Manchester Society,[3] to test the validity of the hopes entertained by many engineers that the exact proportion of nickel to iron found in meteoric iron, namely $2\frac{1}{2}$ per cent, might be adopted to toughen common iron, resulted in a disappointment. The nickel was prepared by melting 30lbs. of roasted ore with 5lbs. of pure sand, 2lbs. of charcoal and 2lbs. of lime, six hours in a furnace, slagged, cooled and remelted with half a pound of roasted ore and a quarter of a pound of pure bottle glass. The nickel thus obtained was fused with Blænavon No. 3 pig iron, $2\frac{1}{2}$ per cent, and run into bars, which on being tested lost 22 to 26 per cent of strength. Another series of experiments in which *pure* nickel was used in the same proportion showed a loss of 17 per cent in strength, but on the other hand a greater proportionate loss of elasticity. The precise object of the experiments was to discover a use of nickel to increase the tenacity of the metal used for mortars and heavy ordnance. During the last two years innumerable tests and experiments have been made for that purpose with more or less success; but the ultimate result appeared to be, in the opinion of the author and others, that for the casting, or rather the construction of heavy artillery, there is no metal so well calculated to resist the action of gunpowder as a perfectly homogeneous mass of *the best and purest cast iron* when freed from sulphur and phosphorus. With malleable iron, such as meteoric iron is, the result of experiments with nickel might be very different.

Iron and Cobalt unite according to Brandt and Bergman in all proportions (the more readily the more cobalt) losing nothing in mellowness and ductility. Hassenfratz agrees that the alloy hammers and welds well but is a little red-short. On the other hand Garnej is of the opinion that cobalt makes iron a little cold-short. Karsten made no experiments.[4]

[2] Karsten, §§ 270, 72.

[3] London Repertory of Patent Inventions No. 776, in Frank. Inst. Journal, p. 280. See also tables, London, E. D. Phil. Mag. June, 1858, p. 486.

[4] Karsten, § 272.

Iron and Zinc can hardly be made to alloy either by direct smelting or by chemical reduction although their surfaces will at a proper heat, like iron and tin. Rinman thought his experiments justified him in saying that zinc made iron softer and more brittle and that a true union was doubtful. Gruelin afterwards tried in vain. Iron will not precipitate zinc from sulphuric acid and so unite with it by reduction, but zinc oxide will refine raw pig metal by abstracting its carbon, pure zinc flying from the furnace in fumes and the rest of the oxide forming a dark-blue black slag with a part of the iron. In Hollunder's iron pots for obtaining grain zinc, after long use, an alloy an inch or more thick will line and finally eat up the whole sides and bottom. Karsten has never found more than 4 to 4½ per cent of iron in zinc and that probably not in the form of a true alloy. Zinciferous iron ores are found and smelted in many countries. The greater part of their zinc is undoubtedly driven off in furnace fumes, as the odor and color of the flames demonstrate, but a good deal of it is condensed as oxide and pure zinc in the cooler upper part of the stack, and finally stops it with a ring-shaped *ofenbruch* as the Germans call it, *schwamm* as it is called in Silesia, full of grains of lead, when that metal is also present in the ore. As the furnace usually makes poor iron when the *schwamm* is broken in to clear the tunnel head, it has been thought that some mischievous union of the zinc with the iron was obtained; but Karsten assigns the trouble to the cooling off of the burden by the interposition of the fragments of the *schwamm*. There is scarcely any zinc free from iron under half of one per cent; but that iron does not contain zinc readily is clear from Karsten's experiments at a coke furnace at the Royal Works in Upper Silesia with 320 cwt. of *galmai* (silicio-carbonate of zinc) containing 16 per cent zinc and 31 per cent iron. The furnace flamed zinc fiercely, its heat was kept very high, the tapped iron looked like best grey, but was very red and soon stiffened, and the whole hearth would scarcely clear; the pigs had a skin which oxidized on cooling, broke perfectly granular, with metallic lustre, looked like good grey iron, was very soft, bent easily but was hard to break, was very tender and crumbled when broken up, as if its grains had no great cohesion. The run gave out neither flame nor odor. The trial lasted two days when suddenly the stack began to

Iron and Zinc.

smoke and zinc flames poured from the tymp, white iron and porous black slag followed and after five days more the furnace with difficulty was saved from chilling up. The iron of the trial was carefully and skillfully refined, giving white and bluish and yellowish flames, etc. etc., and after going under the hammer turned out soft and tough and firm in the extreme without a trace of either cold or red-short quality. The pig iron when analyzed gave a small but indeterminate percentage of zinc but the bar iron not a trace; and if any was present its influence for evil was evidently practically nothing. Subsequent experiments to insure this conclusion were made by refining pig iron mixed with pure zinc, and also with pure oxide of zinc, under the same skillful and accurate superintendence of Herr Paul, leaving nothing to wish in these respects. The bar iron showed not the least defect of quality and by analysis no trace of zinc. Rinman also clears zinc of all evil influence on iron. It merely requires a higher heat to be kept up in the blast furnace and also in the puddling fire. The "galvanizing" or zincking of iron Karsten discusses in § 265.

The following letter received from Mr. Joseph C. Kent of the Cooper Iron Works at Philipsburg New Jersey, on the Delaware opposite Easton, is of importance here:—

"In order to make my process understood I must premise that the difficulty heretofore encountered in working iron ores containing oxide of zinc in blast furnaces has been the gradual clogging up and cooling of the furnace. The oxide of zinc in the ores is volatilized in the blast furnace a short distance above the region of the tuyères; the sudden conversion into vapor of a quantity of the solid ore renders latent a considerable portion of the heat necessary for the successful working of the furnace; at first this evil is not serious because the equilibrium of heat is not destroyed; but the oxide of zinc traversing the height of the furnace condenses on the cool layers of stock encountered in its upward progress; these descend with their *coating* of zinc in addition to the oxide contained in the ore itself, and cause increased vaporization and abstraction of heat, increased condensation in the higher parts of the furnace is the result, and this continues until finally the combustible material in the furnace becomes coated with zinc and resists the action of oxygen

for its combustion, the pores of the ore become clogged and surface coated with zinc until the minerals, almost impervious to the action of the deoxydizing agent, descend raw and unprepared, and complete the chilling and clogging by carrying the oxide of zinc into the crucible or lower part of the furnace.

"To overcome these difficulties resort has been had to various methods; among others working Franklinite ore in low furnaces and consuming large quantities of coal to preserve the requisite temperature, but thus far these methods though entailing great expense have not been successful.

"By my process the difficulties are so far overcome that I work iron ores containing zinc successfully in an ordinary blast furnace and without any additional consumption of minerals and combustibles above the usual requirements of blast furnaces for the smelting of iron ores.

"In an ordinary blast furnace I charge Franklinite or the ores of iron containing oxide of zinc with the usual quantity of coal and such fluxing materials as are shown by a careful analysis of the ores to be necessary. I continue the charging until the furnace shows signs of cooling in the region of the tuyères; I then discontinue the use of zinc ores, and charge with any of the ordinary ores of iron, such as magnetic oxide, sesquioxide, hydrated peroxide, etc., but preferably with ores having a silicious gangue; I continue charging these ores with the usual amount of combustible and fluxing material until the equilibrium of heat is restored and the furnace *scoured;* I then resume the charging of zinciferous ores and alternate as before. I receive the oxide of zinc in the hot-blast ovens and under the boilers, using one set of boilers and hot-blast oven when charging zinc ores; and a second set when charging the ordinary ores; when using the latter ores I clean the oxide of zinc from the boilers and hot-blast ovens which have received it and collect it in bags or boxes.

"In this process I use the gas from the furnace in the usual way for heating the boilers and blast, obtaining the requisite heat by keeping the space under the boilers and in the hot-blast oven unobstructed and clean.

"By this method of working and alternating the ores I have kept a furnace in operation for more than one year continuously; I usually run on zinc ores for four or five consecutive days, and

Iron and Tin.

then change to ordinary ores charging them for three or four days; but these periods wil. vary with circumstances depending on the size of the furnace, qualities of ores and other matters which experience will suggest to every intelligent iron master. JOSEPH C. KENT."

Zinc in small quantities occurs in argillaceous iron ore six inches thick in Meander creek Trumbull county Ohio, in coal measures.[5]

Iron and Lead forms an alloy, not by smelting, but when their mixed oxides are reduced together by coal dust, or when a little pure iron is used to reduce a large body of oxide of lead. Rinman could not make iron receive a small quantity of lead. Morveau's smeltings productive of much iron and a little lead and much lead and a little iron have not been substantiated by later experiments. It is important to know the relations of two metals so often found together in iron ores. Lead often runs out in tapping the blast furnaces that smelt iron ores containing lead, and when these are blown out, lead regulus and oxide, massive and crystallized, beautiful vermilion and silicate of lead are found in the hearth. Karsten never succeeded in smelting bar iron with lead, and pig iron lay white but unalloyed on the lead; when *coal dust* was added with bar iron, pure lead and pure white pig iron core resulted. When *Litharge* reduced by an excess of iron was used there resulted pure lead, lead-bearing iron slag, and white non-lead-bearing iron core. Pure bar iron at a high heat reduced litharge to a pure lead, a black lead-bearing iron slag, and a perfectly fluid iron mass, surrounded by melted lead. Pig iron acted not as pure bar iron, but had a coarse leafy bend, crackled, soon cracked at the edges, was brittle but not the least hard, dissolved without residue in nitric acid and contained no carbon, and on analysis showed itself, although apparently pure iron, to contain 2.06 lead. The lead when analyzed was perfectly free from iron.[6] There seems therefore no cause of anxiety in smelting a lead-bearing iron ore lest the iron should take up and be impaired by lead. Karsten could never find lead in his pig metal.

Iron and Tin alloy in all possible proportions. Bergman alone confines them to two 21 tin : 1 iron and 1 tin : 2 iron; the

[5] Whittlesea, in Mather, 1838, p. 66. [6] Karsten, § 256.

former malleable, harder but duller than tin; the latter non-malleable and too hard to scratch with the knife. Rinman's iron with tin was of coarser grain than cast steel, polished well, was very hard, not easily cracking at the edges under the hammer, not rusting so easily and as having a better clang than pig metal. Lassaigne found an iron-tin alloy formed in his quicksilver retorts as four-sided steel-like needles. Hassenfratz impregnated gunbarrels with tin and found them unmalleable, falling to powder under the hammer. Karsten tried 1 per cent pure English tin to iron ready for refining and found no red-short effect; the iron hammered well though it gave out white fumes and whitened anvil and hammer; but the tin made it highly cold-short, hard to ball in the puddling, and falling to pieces under the hammer at a high heat; and yet this worthless iron contained by analysis merely 0.19 per cent of tin. *Tin therefore lessens in a high degree the tenacity of iron.* The effect of phosphorus in this proportion (0.19) would not be noticeable. It is very needful then to be on the guard for tin in working up old iron as well as pig metal made from ores which may contain tin ore.[7]

Iron and Bismuth may form a chemical union, but about this Brand, Henkel, Gellert and others disagree; these three metallurgists maintain the possibility of an alloy of 1 : 2 to 3 parts; Beaumé denies it; Rinman found the metals separate in smelting. Karsten says iron can take up some bismuth as it can some lead; but bismuth cannot take up iron. He tried refining iron with addition of 1 per cent bismuth with no perceptible effect upon the iron except to make it a little raw in the puddling fire; blue-green flames and odor rose for half an hour and the bloom smelt a little on coming out; but it forged perfectly well and was faultless iron, containing on analysis 0.081 per cent bismuth. Hassenfratz's experiments made good forge iron but a little red-short and made very brittle by plunging in water.[8]

Iron and Copper unite in fixed but not well-understood proportions. Each seems capable of holding but a very small proportion of the other, and the magnetism of the iron in both cases seems undisturbed. All metallurgists agree that pig iron is made firmer, harder and more brittle by copper and therefore Rinman proposes to use copper in anchors, pillars, dies, anvils, rollers, etc. But the influence of copper on bar iron is regarded variously. Rinman in one place affirming that a small quantity of copper makes iron red-short, which in another place he

[7] Karsten, § 258.

[8] Karsten, § 266.

Iron and Copper.

denies. Levavasseur found it in a red-short iron, and most forgemen take the same for granted and believe that the little copper a careless refiner burns off the former-tool will spoil the whole of the iron. Hassenfratz found the immediate alloy of the two both hot and cold-short. Mushet's experiments convinced him that bar iron would unite with copper in all proportions, that the copper-color increased until the alloy was half and half, and then began to pale, and that the hardness increased with the percentage of iron while the tenacity diminished.—**Steel** alloys perfectly with 10 per cent copper but makes a cast steel which will not forge; when the percentage reaches 30 the copper begins to separate and lie at the bottom, white and malleable. Mushet thinks that grey pig iron will combine with very little copper if with any, finding that 5 per cent appeared copper-colored at the cracks and 10 per cent came away in leaves from the surface of the regulus; from all which he argues that iron rejects copper in proportion as it receives carbon. Krilowski at the Ural copper works found that pigs of iron containing from 10 to 14 per cent copper, when remelted, separate so that the copper collects itself in holes below, still retaining however 20 per cent of its own weight of iron, and leaving behind in the iron above from $\frac{1}{4}$ to 2 per cent of copper.

Karsten[9] after narrating the above gives his own experience with Iron and Copper in the Silesian refineries. At first $\frac{1}{2}$ per cent copper kept the refining flame a lively green, and the blooms firm and perfectly malleable without the least red-short show. One per cent made the blooms weld badly and require a third, fourth and fifth heat and even then all the iron was not balled. A bar at the hottest thrust into water gave out a green flame; two out of eight bars broke under the hammer; and an analysis showed in one 0.286 per cent copper. All this seems to show that copper in small quantities although very bad for iron in the puddling furnace is not so injurious to its malleability as was supposed, but is more injurious than phosphorus. In Stengel's experiments with bar iron and steel, red-short showed itself first when the copper had reached 0.44 per cent; but had he used inferior pig iron to make his bar as Karsten

[9] §§ 252, 253.

did, his innoxious limit of copper would have been lower. Very slight percentages of copper in hot refined blooms betrays itself by green flames when water is dashed over them; but the most remarkable test is this: that it requires six times as long to dissolve cupreous iron in sulphuric acid and aquaregia than pure bar iron.[1] Stodart and Faraday mention a steel alloy of 2 per cent copper but deny it the remarkable qualities others have ascribed to copper-steel, saying that it has not the qualities even of good steel. Vazie recommends **Iron with 1 per cent Brass** for steam engine and pump cylinders and wherever cast iron is subjected to unusual friction or corroding water. Karsten's experiments in the Silesian Gleiwitz works confirm the recommendation.[2] Karsten says that copper is a **good solder** for iron where welding is out of the question, or has failed. Brass is still better as more fusible.[3] There was discovered at Nineveh a tripod leg of iron covered with bronze cast over it. Iron and steel cleansed with salammoniac have been cast round with copper, the plates being reheated to a remelting heat; Poole finds the method very practicable. Karsten says that it is useless to plate iron with sulphate of copper for the plating will not stick, but copper, zinc and arsenic inlaid in iron and remelted there with borax sticks. A bronzed appearance is given iron by rubbing it with a diluted vinegar solution of 2 parts crystallized grünspan and 1 part salammoniac.[4] Rinman expresses the same opinion. Hassenfratz permeated gun-barrels with the vapor of lead and copper and spoilt their quality, by making them extremely red-short and also somewhat cold-short, both which facts however Karsten refers to other causes.[5]

In the Irish copper mines of Wicklow now abandoned, the workmen's iron tools becoming coated with copper led to experiments of transmutation. As much as 500 tons of iron were left in the copper waters for a year, and every ton produced $1\frac{1}{2}$ or 2 tons of a precipitate, from every ton of which was obtained 16 cwt. of copper. The iron fell to the bottom of the water as a red peroxide. A bowl was exhibited in Neusohl, Hungary, in 1673 gilded and adorned with silver, bearing this inscription: "Once I was iron now I am copper, I contain silver and am crowned with gold.[6]

Iron and Mercury have relations unknown.

[1] Karsten, § 253. [2] § 254. [3] Karsten, § 255 [4] Karsten, § 255.
[5] § 257. [6] Von Leonhard, translation. Baltimore, 1839, p. 86.

Iron and Silver.

Iron and Silver will alloy in uncertain proportions to the injury of the former. Rinman found that silver would accept about 20 per cent of iron. But even 0.034 per cent of silver in iron lessens its tenacity in a high degree. Stodart and Faraday found that **steel and silver** would mix perfectly so long as they were kept fluid, but on cooling, globules of pure silver were expressed and flowed together over the surface, while the silver in the mass was distributed into strings, the whole appearing like bundles of silver and steel hairs which seemed to be united by forging. If the melt was continued a great while the sides and lid of the crucible were covered with a fine silver dew. A bar of steel containing 1-160th silver yielded globules of silver in the forging and rapidly rusted in air. The silver threads were visible when the proportions were reduced to 1-400th, but not when reduced to 1-500th (or 0.2 per cent) even when forged, acidulated and examined with a microscope. The excess of silver in any proportion above this was thrown off by the steel in the form of dew. This alloy forged well, but was a little harder than cast steel or wootz without showing the least disposition under the hammer or in hardening to edge-cracking or bristling, and is therefore recommended for very superior steel, but Karsten doubts the reality of the alloy.[7]

Rinman found that silver and iron, 5 : 1, made an alloy as malleable as silver and hard enough to be used for bells, rings, fruit knives, etc. Silver will not take up iron 3 : 1. Silver and iron 5 or 6 : 1 by weight is as strongly attracted by the magnet as pure iron, and Coulomb discovered attraction when the iron was but 1-320th, and even so called pure silver obtained from hornsilver and containing but 1-133119th iron disturbed the needle. Morveau saw the alloy of silver and iron separate into two parts, the undermost of silver containing iron and the uppermost of iron containing silver not more than 1-80th, of extraordinary hardness and with a structure of pure iron. Coulomb maintains that silver can hold but 1-150th iron. All agree that iron does not hurt silver; but a great experiment in Upper Silesia proved that even 1.5 per cent of silver did great injury to refined iron, spoiling its forging qualities.[8]

[7] Vol. I. p. 495, § 248, quoting Archiv. f. Borgbau ix. 338, 350; Elsner in Erdmann's Journ. f. Prakt. Chemi. xx. 110.

[8] Karsten, § 247, p. 491.

Iron and Uranium, Palladium, Tantalum, and **Cadmium,** have relationships unstudied and obscure.

Steel and Palladium, Steel and Rhodium, and Steel, Iridium and Osmium, are all alloys celebrated by Stodart and Faraday for excellence and damask beauty. Steel and Rhodium excels the other two in combining tenacity and hardness, making edge tools that require a higher temperature to treat than the best Wootz, which requires a stronger heat than the best English cast steel. The metals seem to unite in all proportions. Three per cent Iridium and Osmium keeps iron from rusting and enables it to become harder by plunging red hot into water, without the addition of carbon; a quality possessed by pure bar iron containing silicium.[9]

Iron and Gold unite easily and in all proportions and so do steel and gold.[1]

Iron and Platinum have not been often alloyed by melting. Stodart and Faraday succeeded in effecting such an alloy but without practical results. Lewis and Rinman had previously melted together pig iron and platinum and thought they obtained a harder and more brittle metal, but this result might be attributable to the coal they used. Stodart and Faraday's experiments with **Steel and Platinum** are celebrated. The mixture is perfect and melts at a lower heat even than steel, equal parts by weight giving an alloy of great strength and admirable polish, not losing its brilliancy, and of a color well adapted for specula, of a specific gravity of 9.862. Pl. 90 + steel 20 makes a perfect alloy. Steel 80 + platinum 10 makes an admirable alloy but with a fine damasked surface. Platinum between the limits of 1 and 3 per cent improves the cutting edge of steel (1.5 being the best), and unlike other metals, protects steel from rust.[2]

Humboldtine, eisenresin, oxalate of iron, mellate of iron, 41.70 protoxide iron, 42.69 oxalic acid, 15.91 water, a capillary, botryoidal, or tabular, sulphur-yellow earth, resulting from the decomposition of plants (?) and found in Hessian *brown coal*, and in Canada shales (T. S. Hunt of the Canada Survey).[3] Mariano de Rivero gives 53.86 + 46.14. Thompson suspected the oxalic acid to be another.[4]

[9] Karsten, § 278. [1] Karsten, §§ 245, 246. [2] Karsten, § 251.
[3] Dana, ii. 465. [4] Thompson, ii. 469.

ADDENDA TO DIVISION I.

Iron and Silicon, page 293.—*Gramenite,* a silicate of iron, in thin aggregated lamellæ of fine grass-green color, produced from the decomposition of some feldspathic rock and the substitution of sesquioxide of iron for alumina; analyzed by Bergemann $\ddot{\mathrm{Si}}$ 38.39 $\dddot{\mathrm{Fe}}$ 25.46 $\dddot{\mathrm{Al}}$ 6.87 $\dot{\mathrm{Fe}}$ 2.80 $\dot{\mathrm{H}}$ 23 36, etc.=100.[1]

Seladonite, a silicate of iron, in the form of a green plastic earth, decomposed from basaltic tufa, on Mt. Baldo, and got in Kaaden, Bohemia, giving V. Hauer $\ddot{\mathrm{Si}}$ 41.0 $\dot{\mathrm{Fe}}$ 23.4 $\dot{\mathrm{H}}$, $\ddot{\mathrm{C}}$ 19.3 $\dot{\mathrm{Ca}}$ 8.2 $\dddot{\mathrm{Al}}$ 3.0 $\dot{\mathrm{K}}$ 3.0 $\dot{\mathrm{Mg}}$ 2.3.[2]

Acmite, a bisilicate of protoxide and sesquioxide of iron, gave Rammelsberg a mean of $\ddot{\mathrm{Si}}$ 51.66 $\dddot{\mathrm{Fe}}$ 28.28 $\dot{\mathrm{Fe}}$ 5.23 $\dot{\mathrm{Na}}$ 12.46 $\ddot{\mathrm{Ti}}$ 1.11, etc.

Ægerine, a bisil. prot. and sesq. iron, gave him $\ddot{\mathrm{Si}}$ 50.25 $\dddot{\mathrm{Fe}}$ 22.07 $\dot{\mathrm{Fe}}$ 8.80 $\dot{\mathrm{Na}}$ 9.29 $\dot{\mathrm{Ca}}$ 5.97 $\dot{\mathrm{Mn}}$ 1.40 $\dot{\mathrm{Mg}}$ 1.28 $\dddot{\mathrm{Al}}$ 1.22 $\dot{\mathrm{K}}$ 0.94.

Babingtonite, a bisil. prot. and sesq. iron, gave him $\ddot{\mathrm{Si}}$ 51.22 $\dddot{\mathrm{Fe}}$ 11.00 $\dot{\mathrm{Fe}}$ 10.26 $\dot{\mathrm{Ca}}$ 19.32 $\dot{\mathrm{Mn}}$ 7.91 $\dot{\mathrm{Mg}}$ 0.77 $\dot{\mathrm{Na}}$,$\dot{\mathrm{K}}$ traces.

Arfvedsonite, a bisil. prot. and sesq. iron, gave him $\ddot{\mathrm{Si}}$ 51.22 $\dddot{\mathrm{Fe}}$ 33.75 $\dot{\mathrm{Fe}}$ 7.80 $\dot{\mathrm{Na}}$ 10.58 $\dot{\mathrm{Ca}}$ 2.08 $\dot{\mathrm{Mn}}$ 1.12 $\dot{\mathrm{Mg}}$ 0.90 $\dot{\mathrm{K}}$ 0.68.

These four consist of $\dot{\mathrm{R}}^3\,\ddot{\mathrm{Si}}^2 : \dddot{\mathrm{Fe}}\,\ddot{\mathrm{Si}}^2$ :: 1:1 1:2 3:1 and 2:3; the silicates of protoxide and silicates of sesquioxide being isomorphous.[3]

Iron and Sulphur, page 306.—*Rœmerite* is a new iron pyrites described by J. Grailich from the Rammelsburg mines, coarsely granular and partly crystalline, giving to L. Tochermak a mean of $\dddot{\mathrm{S}}$ 41.54 $\dddot{\mathrm{F}}$ 20.63 $\dot{\mathrm{Fe}}$ 6.26 $\dot{\mathrm{H}}$ 28.00, etc.[3]

Iron and Potassium, page 314.—Dr. Eckert informs me that it has been the custom for many years to sell for manure the white dust which is obtained in cleaning out the gas rooms and pipes of the anthracite furnaces at Pinegrove and Reading owned by Eckert & Myers, as 50 per cent of it consists of Potassa. Its effect upon the soil is equal and superior to that of imported guano.

Iron and Aluminium, page 316.—For process to separate Alumina from Iron see American Journal of Science and Art, New Haven, 1858, page 401.

PAGE 320.—OBSERVATIONS ON ATOMIC VOLUMES, WITH CONSIDERATIONS ON THE PROBABILITY THAT CERTAIN BODIES NOW CONSIDERED AS ELEMENTARY MAY BE DECOMPOSED.

PROF. DUMAS, at the British Association, alluded to the solubility of some substances, and the insolubility of others, giving many instances of the difference of this quality in regard to solution in water, sulphuric and strong acids, and referred to Berthollet's views and experiments on this subject. The measure of volume of bodies, he thought, might be represented with as much facility as the weight; thus, for example, magnesia and sulphuric acid may have their volumes numerically expressed before and after combination, and also graphically by lines. Magnesia with sulphuric acid showed a certain degree of condensation, lime a greater condensation, and barytes the greatest condensation; and these he could represent and reason on as well by lines of different lengths as by figures or by words. The degree of condensation had also relation to the quality or degree of

[1] Dana, Amer. Jour. 1858, p 348. [2] Dana, Amer. Jour. 1858, p. 358.
[3] Sitz. Akad. Wien, 1858, p. 272, in Amer. Jour. 1858, p. 352, 351

solubility. Thus, sulphate of magnesia was very soluble, sulphate of lime but little soluble, and the greatly condensed sulphate of barytes was insoluble. He then pursued the analogy with the chlorides, comparing the chloride of sodium with the extreme case of the chloride of silver. After graphically expressing the solubility of bases with sulphuric acid by lines, he proceeded to show that the relative volumes of the elements chlorine, bromine, and iodine, could be perfectly represented by lines equal in length. Prof. Dumas said that when a number of metals are represented by lines, at first they seem in confusion, and it would appear like an impossibility to arrange them in a system of lines, to permit their relations to appear; but when considered in relation to the substitution of one property for another, or of the substitution of one substance for another in groups, then their arrangement became easy. Many examples were given of groups of bodies such as the alkalies, earths, etc., arranged in the order of their affinities. He also called attention in the Triad groups, to the intermediate body, having most of its qualities intermediate with the properties of the extremes, and also that the atomic or combining number was also of the middle term, exactly half of the extremes added together; thus, sulphur 16, selenium 40, and tellurium 64. Half of the extremes give 40, the number for the middle term. Chlorine 35, bromine 80, and iodine 125. Of the alkalies, lithia, soda and potassa, or earths, lime, strontia and baryta, afforded, with many others, examples of this coincidence; hence this suggestion, that, in a series of bodies, if the extremes were known by some law, intermediate bodies might be discovered; and, in the spirit of these remarks, if bodies are to be transformed or decomposed into others, the suggestion of suspicion is thrown upon the possibility of the intermediate body being composed of the extremes of the series and transmutable changes thus hoped for. Prof. Dumas then showed that in the metals similar properties are found to those of non-metallic bodies; alluding to the possibility that metals that were similar in their relations, and which may be substituted one for the other in certain compounds, might also be found *transmutable*, the one into the other. He then took up the inorganic bodies, where substitutions took place, which, he stated, much resembled the metals. After discussing groups in Triads, Prof Dumas alluded to the ideas of the ancients, of the transmutations of metals, and their desire to change lead into silver, and mercury into gold; but these metals do not appear to have the requisite similar relations to render those changes possible. He next passed to the changes of other bodies—such as the transmutation of diamonds into black lead, under the voltaic arc. After elaborate reasoning, and offering many analogies from the stores of chemical analysis, Prof. Dumas expressed the idea that the law of the substitution of one body for another in groups of compounds might lead to the transformation of one group into another at will; and we should endeavor to devise means to divide the molecules of one body of one of these groups into two parts, and also of a third body, and then unite them, and probably the intermediate body might be the result. In this way, if bodies, of similar properties and often associated together, were transmutable one into the other, then, by changes, portions of one might often, if not always, be associated with the other. Thus, in nature, where chlorine occurred, iodine and bromine might also be found, and always would be if they were transmutable the one into the other. Cobalt is thus mysteriously associated with nickel, iron with manganese, sulphur with selenium, etc. In the arts, during operations, when certain radicals were produced, analogous ones were found constantly to be associated. In the distillation of brandy, oil of wine is always an associated result. Dr. Faraday expressed his hope that Prof. Dumas was setting chemists in the right path; and although conversationally acquainted with the subject, yet he had been by no means prepared for the multitude of analogies pointed out. Mr. Grove spoke of the importance of the views; as, by knowing the extreme compounds, it might serve as a guide in experiments, and as a check to the results. He adverted to the allotropic condition of substances when their principal characters were changed, but their chemical qualities were unaltered; thus, carbon in the state of diamond had a change of property so complete that it had one of the properties of metals given or transferred to it by its conducting power for electricity under these conditions, and its other forms were states resistant to electric passage. He thought this fact, of certain bodies having two sets of physical properties, with greatly differing character, might, with this law of the substitution of one set of chemical qualities for another in a compound group, give the hope of the great realization of some of the ideas embodied in the views of the possible transformation of one body, at will, so as to possess the properties of all others.—*Annual of Scientific Discovery*, 1852, p. 167.

Iron and Zinc, page 325.—Elias Baker's hematite ore in central Pennsylvania (Alleghany Furnace, etc.) is mingled with zinc and makes a superior bar iron when smelted with charcoal, but a rotten iron when smelted with coke. (H. N. Burroughs.) Merion Furnace has been making iron of $\frac{3}{4}$ hematite ore mixed with $\frac{1}{4}$ zinc-iron refuse of the Newark works in New Jersey, which refuse contains 2 per cent of zinc and is sold at $6.00 per ton. A hundred tons of the iron so made worked equal to the best Baltimore iron. (Dr. Eckert.)

ORE.

DIVISION II.

IRON AS AN ORE IN THE UNITED STATES.

INTRODUCTION.

To classify the ores of the United States it is needful to distinguish the geological belts or regions into which the surface is divided. The commonest terms are the best where they involve no error; and as the terms **primary, secondary, tertiary** continue to express well enough the largest divisions of geological time, or groups of geological formations, they will be employed without apology. The Primary rocks form a back bone to the Atlantic seaboard; the Secondary rocks cover the centre of the country; the Tertiary rocks spread around the edges. The Primary are destitute of fossils and show no traces of ancient animal or vegetable life, excepting in the presence of phosphorus and carbon in certain peculiar forms; the Secondary and Tertiary rocks are full of fossils, layer upon layer, life upon life, creation after creation, a scale of which each number is an advance upon the rest, a Jacob's ladder on which the form-angels ascend and at the top of it the Son-of-man. The Primaries are all metamorphosed or changed from their original state as muds, clays, marls, sands, gravels, osars, bogs, iron sediments, metallic precipitations and what else, into clayslate, chlorite, talc, mica slates, breccias, gneiss, granite, marble, dolomite, serpentine, specular and magnetic iron ore, and what not; their stratification or bed-plates so squeezed, bent, fractured, mashed together, overturned, infiltrated, crystallized and split crosswise into roofing slates or building stones as to make their examination difficult and uncertain. The Secondaries are sometimes metamorphosed also, and in such cases are almost undistinguishable from the primaries. The Tertiaries are very seldom so affected, and never in the United States, unless it be in the Rocky Mountains.

This **metamorphic action** has been the production of an

unknown agency; it has been fashionable to say **fire;** it is coming into fashion to say **water.** In the neighborhood of trap-dykes and other so-called fire rocks the change is usually seen in perfection. But chemical action is now known to be a sufficient cause for the grandest metamorphic phenomena. It is no longer proper to speak of marble as a *plutonic* or fire rock; it is a *primary* rock only in the sense of *changed*, or crystalline. Serpentine was once called a fire rock, but now it is settled to be a chemical production under a warm sea. Good geologists look upon mountains of granite and sienite no longer as upbursts of molten matter from the interior of the planet, but as sedimentary rocks hardened and crystallized by gentle heat and acid water, and even regard veins of quartz as infiltrations from above rather than ejections from beneath. The occurrence of the precious metals, copper, silver, lead and even gold is explained by many who are authorized to speak as a precipitation in crevices from overlying waters or as original deposits at the bottom of the ancient seas. The prejudice instilled by our familiarity with **iron in a molten state** has left it hitherto an exception to this rule; as a prejudice in favor of the igneous origin of all metallic veins obliged geologists to adopt the theory of gaseous impregnation to explain "fahlbands" or rocks through which pyrites is disseminated. But such a prejudice cannot last. Evidence is accumulating year by year sufficient to remove all doubt of the common sedimentary origin of iron even under forms which once were universally accepted as volcanic. Some of this evidence will be presented to the reader in the following pages, not in the well-ordered detail which would be proper in a book devoted to theoretical questions, but incidentally in connection with the description of the localities where primary ores abound.

The point to be here kept in view is of a different and practical kind. The different ages of creation have been marked as plainly by different metallic deposits forming characteristic mining regions, as by stony deposits or by the living creatures whose remains they have successively entombed.[1] The Prima-

[1] Prof. Hall of Albany has been among the first to see and announce this important principle. At the Providence Meeting of the American Association, in reply to a question he stated that all the rocks below the palæozoic, which occurred in any considerable quantities in this country, were metamorphic from sedimentary rocks. Not only the great systems of these rocks, but even subordinate portions of them had been deposited under somewhat different circumstances physically and chemically. Although some

ries show everywhere the outcrops of magnetic, specular and red oxide iron ores; the Secondaries contain the sulphurets and carbonates of iron; the Tertiaries are the home of the bog ores. Not that these three forms are strictly confined each to its own age and excluded from the other two; for the sulphuret of iron is found from the oldest to the latest stratum of the earthcrust, and bog ores have formed in all ages wherever chalybeate waters reached the upper air; but each group of ores characterizes its own group of formations. The Primary age had its own conditions of deposit quite as different from those of the Secondary age as these were in their turn from those of the Tertiary or present age; and these distinctions were intensified by subsequent chemical and volcanic agencies. The rule of the painter's pallet here obtains; the colors deaden and grow neutral the more they are mixed; the oldest rocks are the simplest and best individualized, while the latest deposits, having been oftener worked over, are the most compound and like each other.

It is in primary countries like the Blue Ridge and Black Mountains of Virginia and Carolina, or the Adirondacks of northern New York, or the great wilderness of northern and western Canada, that one must expect the primary or crystalline ores. In the Secondary or older unchanged formations one must look for beds of carbonate of iron and deposits of brown hematite. In the Tertiary or later softer sands and marls one meets with bog ore at every step.

In practical Iron-making the series of ores is somewhat different and will be taken in the following order:—

1. The **primary specular, magnetic** and **red oxide.**
2. The **brown hematites.**
3. The **fossil ores** of the Upper Silurian rocks.
4. The **carbonates;** especially of the coal measures.
5. The **bog ores** of the present surface.—But a general sketch of the surface geology of the United States is necessary before describing these ores in detail.

shells and sandstones in different formations might have considerable similarity, still they presented differences, and these slight differences were wrought in metamorphism. He was satisfied that when our metamorphic rocks came to be more thoroughly known, every group that had had any considerable characteristic in its original formation would in its metamorphic state be found to present such peculiar minerals as to characterize it as perfectly as the fossiliferous rocks are characterized by their fossils.

The continent of North America divides itself geologically into two great parts, the east and west. These were two continental islands down to the close of the Tertiary age. A narrow ocean joined the Gulf of Mexico with the Polar Sea. All to the east was Primary and Secondary rock; all to the west was an archipelago of mountain peaks and ridges, sometimes lifted high enough to make great tracts of land, and as a whole resembling probably the region of the southwest Pacific, as to its general distribution of land and water. Among these islands and throughout the intervening ocean strait where now the innumerable western branches of the Mississippi and McKensie's River flow, were laid to rest successively through an unknown length of ages the Cretaceous and Tertiary strata, at the same time that they were being deposited in like manner in the Atlantic, and over what is now the Savannas of the Orinoco, Amazon and Paraguay in South America, between the then great island of Brazil and the long strait narrow island of the Andes, which must have turned the tidal wave at that time northward in very much the same way as the eastern coast of South America does now.

Neglecting the Rocky Mountain Archipelago and **regarding only the eastern continent** of North America, at the beginning of the Tertiary era, we see it composed entirely of Secondary rocks except a primary back-bone ridge stretching from New York city to Augusta, Georgia; another stretching crosswise of the first from Maine to Lake Superior; a mass of primary rocks in northern New York; a small island of primary in Missouri; and certain unknown regions in Labrador and Greenland, which seem always to have stood above the level of the ocean from the earliest times. In these exceptional regions lie those deposits of crystalline iron ore which have excited the admiration and cupidity of mankind since the first fabulous reports of their existence issued from the forests which still surround the most of them. Regarding these primary regions as still more ancient islands at the opening of the Secondary era, we may imagine them surrounded and sometimes over-capped by the successive secondary formations until the intervening seas were filled up level with the surface of the water, forming at last a continental swamp in which the coal-measures were formed and then the whole was lifted under a side pressure

which threw the crust into wrinkles miles in width and hundreds of miles in length, the tops of which were planed away leaving the present surface marked with secondary mountains and valleys in which the secondary or uncrystallized iron ores abound. Then followed as has been stated the deposits of the Tertiary age around this continental island of secondary with its back-bones of primary rocks.

These formations are subdivided as follows:

Quaternary			Or river formations.
Tertiary[2]			Or marls and sands of the coast.
Cretaceous[3]			
Newer Secondary[4] (New red sand) (Permian)			Connecticut Valley, of Middle New Jersey, Newark, Norristown, etc., the Richmond, Dan river and Deep river coal-measures.
Older Secondary.	Old red.	XII.	Coal-measures, Anthracite and Bituminous.
		XI.	Red shale. Subcarboniferous Limestone. Protocarboniferous or early coal measures.
		X.	White sandstone, *making mountains.*
		IX.	Red sandstone. Catskill group
	Devonian.	VIII.	Olive sandstones. Portage and Chemung. Olive slates. Hamilton group. Black slates. Marcellus shales. Cement limestones. Upper Helderberg.
		VII.	Oriskany sandstone, *making hills.*
	Upper Silurian.	VI.	Limestone. Lower Heldelberg.
		V.	Red shales. Clinton group. Marls and fossil ore. Slates.
		IV.	White sandstone, *making mountains.* Medina.
	Lower Silurian (Taconic.)	III.	Hudson river slates;
		II.	Magnesian Limestone; Hematite ores.
		I.	Potsdam Sandstone and Slates,—
Primary.			Huronian; western Canada; Blue Ridge; northern New York, Wisconsin and Missouri specular and magnetic iron ores, red oxide of iron, etc.
			Laurentian; Eastern Canada and northern New York and perhaps Carolina; limestones, conglomerates, slates, etc.

[2] [3] Subdivided into IV. Postpleiocene, III. Pleiocene, II. Miocene, I. Eocene by Lyell. In Nebraska Hayden & Meek have founded five groups A. Miocene, B. Eocene, C. No. 4 and 5, D. No. 2 and 3, E. No. 1 of their section. (Proceedings of the Acad. Nat. Hist. Phil. Nov. 1856 and in May 1857.) And in New Jersey Cook has five formations of Cretaceous underneath his *a* Tertiary Green-sand to correspond with Hayden & Meek's C. D. E., to wit, *b* yellow limestone and green-sand, *c* iron shell-sand, *d* green-sand, *e* dark clays, *f* dark blue, ash and white clays and micaceous sand with thin seams of coal, fossil-wood and sulphuret of iron. (Idem May 1857, p. 13.)

[4] Not yet well subdivided in America. In Europe under the *lower cretaceous*, come Regnault's 7th group Jurassic system of Côte-d'or, 8th group Trias system of Thuringenwald, 9th group Gres de Vosges system of the Rhine, 10th group Pénéén system of the Low Countries and Pays de Galles lying on the Coal-measures. The Permian rocks of Russia come between these and belong according to some geologists to the Newer and according to others to the Older Secondaries or the Coal-measures. The late Discoveries of Permian fossils in Illinois, Missouri and other parts of Central North America have still further confused the question.

The New York geologists gave local names to most of the subdivisions of the Older Secondary rocks, some of which are in constant use, as the **Hudson river slates** (III.), the **Potsdam sandstone** (I.), the **Clinton fossil ore** (V.), and therefore these names will frequently occur in the following pages. Prof. H. D. Rogers has substituted a poetical nomenclature for the original and convenient enumeration of the same series as it shows itself in Pennsylvania, Maryland and Virginia, and a few of his names such as **Primal sandstone** (I.), **Auroral limestone** (I.), **Matinal slate** (III.), **Surgent fossil ore** (V.) will probably stick fast in geological usage, when the rest are forgotten. But in a general work like this the older European names are equally practical, more widely known, more comprehensive, and less open to minute discussion. Those in commonest use are **Lower Silurian** (I. II. III.) **Upper Silurian** (IV. V. VI.) **Devonian** (VIII. IX. X. XI.) **Old red sandstone** (IX. X. XI.) **Subcarboniferous** (XI.) and **New red sandstone** a general term for all the later secondary rocks from the Permian to the Cretaceous. No practical man need be misled by the general use of these expressions; and no geologist can be, where the local details are given. Returning now to the description of the surface of the country:

The primary ores of New Jersey, etc., occur like those of northern New York in a **belt of subsilurian rocks** forming the mountain region, known where it crosses the Hudson river as the Highlands, and where it crosses the Delaware river as the Easton or Durham hills. Between the Schuylkill at Reading and the Susquehanna at Columbia it is represented by the Welsh mountain, sinking westwardly beneath two united valleys of Lower Silurian rocks which are themselves partially covered by a sheet of Permian or New Red deposits. Beyond the Susquehanna it rises and widens into the South mountain, and after crossing the Potomac becomes the great Blue Ridge of Virginia. In North Carolina it spreads grandly over the surface of the State, fills the southeast corner of Tennessee and settles into the broad low metamorphic country of northern Georgia, to disappear beneath the cretaceous curtain of southern Alabama.

This **belt of subsilurian**, *subpalæozoic*, *azoic*, *hypozoic*, *hypazoic*, *taconic*, *metamorphic*, *primary* or better still since Mur-

ray's study of its northern outcrop in Canada West, **Huronian** rocks—for by all these names are they known—this central belt of short, parallel, half disconnected, half confused mountains of nearly the oldest rocks we know, is a great line of demarcation in American geology. Uplifting as it does on its two flanks the first formations which contain fossils (the Lower Silurian) and in fact uplifting the eastern half of the American continent a few hundred feet above the waves, it has done this so unequally that only the country lying west of it has reaped any permanent benefit from the uplift. In that direction lies a continental region of these older secondary or ancient fossil rocks the last of which was coal. Towards the east these older secondary rocks had only their edge brought up above the Atlantic, and still remain bodily submerged, constituting those astonishing deep sea steeps and slopes, hollows and ridges, described in the reports of the officers of the Coast Survey. Over these were laid in comparatively recent geological times the cretaceous and tertiary formations which have been slowly rising and forming the broad "tide water" or Atlantic coast country of the southern States commencing in New England and terminating in Mexico—sweeping round the southern end of the central belt of older rocks at Montgomery in Alabama and up the Mississippi, Tennessee and Cumberland valleys to Paducah and the mouth of the Ohio. So we have

1. The Highland-Southmountain-Blueridge **central Huronian belt** crossing the great rivers at West Point, Easton, Reading, Columbia, Harper's ferry, Charlottesville and Lynchburg, and broadening into the Black mountains of western North Carolina—everywhere exhibiting beds of magnetic or primary iron ores, with zinc and copper; then

2. On the right of it going south, the Great Valley, a wide, regular, fertile, densely populated, gently undulating **plain of Lower Silurian** rocks, on which stand the inland cities of Newburg, Easton, Reading, Harrisburg, Chambersburg, Winchester, Nashville and Chatanooga in Eastern Tennessee, with a multitude of smaller towns and villages, of ancient date (to speak with an American tongue), and full of iron-works smelting brown hematite ore-deposits found principally upon its eastern side; then

3. Crowded to the west of the Great Valley the **Appalachian**

mountains; **Outcrops of the Upper Silurian and Devonian** sandstone formations, going down and coming up in a complicated series of waves, covering the surface with a wonderful topographical picture of long, thin, sharp parallel mountains, all of a uniform height (about a thousand feet) with level crest-lines drawn against the sky for many miles and notched even down to their bases at intervals, streams and rivers of every conceivable size coming out through the deeper notches, and long, narrow, secluded rural valleys lying in behind. The bottoms of many of these valleys are the upturned edges of the Lower Silurian rocks of the Great Valley, coming to the surface along steep anticlinal axes of uplift, and bringing with them all the elements to form similar brown hematite ore beds; therefore many iron-works are scattered through these Lower Silurian limestone Appalachian Valleys. Others consist of monoclinal Upper Silurian or Devonian rocks, containing valuable deposits of a very different kind, the fossil ore hereafter to be described; and these have also their iron-works, but comparatively few. Then

4. Behind this Appalachian labyrinth (which is from fifty to one hundred miles in width, begins in Canada East, ranges through Vermont, southern New York and middle Pennsylvania, crosses the Potomac between Harper's Ferry and Cumberland, occupies the southern line of Virginia from Abingdon to the Cumberland Gap (over into Kentucky), and gradually narrows under the cliffs of the Huntsville Mountain to a point near Montgomery in middle Alabama), towers the long almost unbroken wall of the true **Alleghany Mountain crest**, where the whole bulk of the Devonian and Subcarboniferous rocks come in, and on their top the gently westward-sloping knife-edge of the first or lowest coals. Everywhere about three thousand feet above the sea this escarped brim of the Great Basin is the true boundary of the Western Country. Over it all roads south of Albany climb to reach the West. It is taken in flank however by the New York canal and Central railroad, because it begins at the Hudson in the grand terminal plateau of the Catskill mountain, covers all northwestern Pennsylvania from the heads of the Juniata to Lake Erie, and all western Virginia, and eastern Middle Tennessee, and terminates southward in a similar but much narrower plateau in Alabama. Along its eastern edge crop out the subcarboniferous limestone and iron

ore of No. XI. back of which lie the enormous fields of coal with their included iron ores and surface deposits of bog. Lastly returning to the east

5. We have the **cretaceous, tertiary,** and **post-tertiary deposits** to the left of the Great Central Belt as we go south, covering the southern half of New Jersey, all Delaware and eastern Maryland, eastern Virginia, North and South Carolina (up to the gold region), two-thirds of Georgia and Alabama, nearly all of Mississippi, the western parts of Tennessee and Kentucky between the Mississippi and the Tennessee rivers, and west of the Mississippi river all the country south of Missouri (except a part of Arkansas) as far as the Rio Grande; and northward, all between the 99° of longitude and the Rocky Mountains, far into the British possessions, excepting only the Black Hills and a few other and still smaller islands of older rocks which stood above the cretaceous and tertiary oceans, or were projected through its deposits from below. Bog iron ore characterizes this great belt in New Jersey, Delaware and Maryland, and in the West.

Meteoric iron being found in the United States ought to be treated as one of its ores, but its scarcity makes its practical importance so infinitely small that it would be absurd to treat it so. It is moreover an exceptional substance coming from the sky upon the earth and therefore its discovery cannot be regulated on geological principles. Its intrinsic interest however to speculative minds, its intimate relations to the primary ores, and its bold suggestion (especially since the exploration of the Lake Superior native copper region) that perhaps immense masses of native iron also may exist as part of this earth's envelope, justify us in reviewing its phenomena at some length; and this is the fitting place.

Professor C. U. Shephard of New Haven has published the following catalogue of meteoric irons with the date of their fall:

1.	Senegal, Africa	Found	1717.
2.	Krasnojarsk, Government of Jeniseisk, Siberia	"	1749.
3.	Saxony (Steinbach, near Eibenstock)	"	1751.
4.	Agram, Croatia	Fell May 26,	1751.
5.	Tecuman, Otumpa, Argentine Rep., S America	Found	1783.
6.	Bahia (Bemdego), Brazil	"	1784.
7.	Xiquipilco, Toluca, Mexico	"	1784.
8.	Zacatecas, Mexico	"	1792.
9.	Cape of Good Hope	"	1793.
10.	Bitberg, in the Eifel, Rhenish Prussia	"	1805.
11.	Texas (Red River), U. S. A	"	1808.
12.	Rasgata, New Granada, South America	"	1810.
13.	Elbogen, Bohemia	"	1811.

14. Durango, Mexico................................. Found 1811.
15. Lenarto, Saroscher Comitat. Hungary................ " 1814.
16. Lockport, New York, U. S. A........................ " 1818.
17. Burlington, Otsego county New York, U. S. A......... " 1819.
18. Guildford, North Carolina, U. S. A.................. " 1820.
19. Atacama, Bolivia.................................. " 1827.
20. Caille, Dep. du Var, France........................ " 1828.
21. Bohumilitz, Prachiner Circle, Bohemia............... " 1829.
22. Claiborne county Alabama, U. S. A.................. " 1834.
23. Dickson county Tennessee, U S. A............. Fell July 30, 1835.
24. Black Mountain, Buncombe Co. N. Carolina, U. S. A... Found 1835.
25. Asheville, Buncombe county North Carolina........... " 1839.
26. Putnam county Georgia, U. S. A..................... " 1839.
27. Cocke county (and Sevier county), Tennessee......... " 1840.
28. Newberry (Ruff's Mountain), South Carolina, U. S. A... " 1841.
29. Green county (Babb's Mills), Tennessee, U. S. A....... " 1842.
30. St. Augustine's Bay, Madagascar..................... " 1843.
31. Arva, (Szlanicza) Arvzer Comitat, Hungary........... " 1843.
32. Otsego county New York, U. S. A.................... " 1845.
33. De Kalb county Tennessee, U. S. A.................. " 1845.
34. Carthage, Tennessee, U. S. A....................... " 1846.
35. Chester county South Carolina, U. S. A............. " 1847.
36. Braunau, Königgretzer Circle, Bohemia......... Fell July 14, 1847.
37. Seelüsgen, Neumark, Brandenberg................... Found 1847.
38. Schwetz, Prussia.................................. " 1850.
39. Salt River, Kentucky, U. S. A...................... " 1850.
40. Pittsburg, Pennsylvania, U. S. A................... " 1850.
41. Seneca Falls, Cayuga county, U. S. A........... Found since 1850.
42. Lion River, Namaqua Land, South Africa........ " " "
43. Union county Georgia, U. S. A................. " " "
44. Tazewell, Claiborne county Tennessee, U. S. A... " " "
45. Santa Rosa, New Mexico....................... " " "
46. Tuczon, Sonora............................... " " "
47. Chili.. " " "
48. Haywood county North Carolina, U. S. A....... " " "
49. Orange River, South Africa................... " " "
50. Madoc, Canada West.............................. Found 1854.
51. Mississippi, U. S. A............................... " 18—.

DOUBTFUL METEORIC IRONS (*several of which are destitute of nickel, chromium and cobalt, and do not afford the true Widmannstaattian figures; or if containing the usual meteoric metals, the masses have been altered and disguised by a strong artificial heat.*)

Randolph county North Carolina, U. S. A., 1822.
Sterlitamal, Orenberg. Russia, 1825.
Bedford county Pennsylvania, U. S. A., 1828.
Scriba, New York, U. S. A., 1830.
St. Matthews, South Carolina, U. S. A.
Walker county Alabama, U. S. A., 1839.
Homony Creek, Buncombe county North Carolina, U. S. A., 1845.

Montgomery, Vermont, U. S. A. **Meteoric Ore.**
Achen (Aix-la-Chapelle), France.
Collina, de Brianza, Brazil.
Long Creek, Jefferson county Tennessee, U. S A., 1853.
Poictiers, France.

The whole subject of **meteoric iron** is discussed in extenso by Herr C. J. B. Karsten, in a memoir "*über feuer-meteore*" read in the Academy of Sciences at Berlin Jan. 13, 1853. He gives, as all do, to Chladni the credit of setting at rest the question of the celestial origin of these erratic masses; suggests that we know nothing of the changes they undergo in their descent; divides them into meteor-stone and meteor-iron masses; leaves to future science the task of determining to which of these classes those belonged which plunged through space against the earth in its antepalæozoic, palæozoic, secondary or tertiary ages; and excuses Chladni for not anticipating the fact that an exhaustive analysis of meteors has determined the presence of nickel and cobalt not to be a sine quâ non in the case of some meteoric masses of iron the fall of which has been observed, and therefore not to be a shibboleth to try those by of whose possible descent there is no record.[5] He shows how the common dark (subsilicate of the black oxide of iron) rind of meteors may be weathered off in their descent and be therefore also no criterion. Although the *observed* fallings of stone meteors have been much more numerous than of iron masses, yet it is the iron masses and not the meteor stones that have been found upon the surface of the earth. Many a meteor may have been so oxidized while lying countless ages on the surface of the earth as to have lost its original nature and form; and many a massive meteor, thrown off when the rind of its mother orb burst on cooling, and itself reaching the earth so quickly that its heat was still great, may have cooled under the action of the atmospheric oxygen into a very different body from what it was in space. Many a block of stone may lie on plain or mountain side among the earthborn rubbish of the cliff, without exciting a suspicion of its heavenly origin, as many a mind of the divinest mould lives unsuspected in a savage state or walks unrecognized among the crowds of city life. There may have been ages of its history when clouds of these meteors of both kinds met the earth, and spread themselves in blocks or masses or flattened layers on its surface. And if so, subsequent deposits must have covered them up, and denudation may have swept them away again or made sections of them, exposing their outcrops like terrestrial beds of rock or iron ore. The geologist at all events must be prepared to encounter cases of this kind.

[5] Prof. Peter A. Brown of Lafayette College published in 1844 an essay or lecture on solid meteors their comparative velocities and heights, the cause of their heat and *fourteen* theories of their origin. Halley's in the Phil. Trans. No. 30: Luke Howard's in his Meteorology: Soldaté's of Siena; Dr. Reynolds' in Silliman's Journal vol. i. p. 266, 1818; Dr. Blagden's Phil. Trans. 1784; Dalton's in his Meteorol. Obser. Manchester 1834, p. 243; Brewster's, Ed. Phil. Journal; Hutton and Laplace—from the moon; Newton—from comets' tails; Chladni, Franklin and Rittenhouse—planetary bodies; Ferguson, Olbers, etc.—fragments of an exploded planet; Quetelet—a planetary zone of ærolites; Boubee—an exploded comet. In the Edin. Phil. Journal 223 vol. i. is a list of 177 meteoric stones that have fallen from the earliest times to the year 1819. M. Messier in 1777 saw at noonday a prodigious number of black spots pass across the sun's disc. vol. 12, Mem. Roy. Acad. Brussels. See also the splendid daylight pyrotechnic exhibition seen in 1820 by the subprefect at Embrun described in the Annales de Chimie Oct. 1825.

Such Karsten thinks to be the nature of the curious iron deposit near Thorn in Central Europe, discovered by Herr Grodski of Wolfsmühle in 1852 and covering at least 700 acres of his ground, within 4 inches of the top of the soil. The ore outside was the common brown and yellow iron stone, but when freshly broken was peculiar of its kind, looking as if half melted, partly compact partly porous, a black lava-like substance glassy and slaggy in its whole appearance. But the first steps of an analysis showed that it could have been no result of artificial smelting, mixed as the native iron was with an olivine mineral. The mixture of unchanged meteoric iron and meteoric stone was so fine that when the mass was reduced to powder a magnet would not take up all the iron free of the olivine. No iron works were ever heard of in the neighborhood of Thorn, nor could a vast number of them have accomplished such a result. The ore overlies the whole area in bars or plates two or three feet long, three to six inches wide and two or three inches thick, shoved against and between each other in one place where there is a ravine and water course for 170 feet of face, but elsewhere separated by greater or less spaces; all lie on sand and scarce one appears above the soil. Most of the meteors seem therefore to have fallen in the ravine, where the cubic contents of only half the mass as measured would amount to 4,800 cubic feet or 360 tons, and the whole mass as known in 1853 could not be less than 1,000 tons, the fall of which one mile further to the west would have destroyed the whole town of Wolfsmühle had it then existed and the tradition of the event would have been indelible from the oral or written history of the land. As no such tradition exists, the starry avalanche must have happened in a wilderness of woods, unless the story of old Sebastian Münster relates to this event. "In the year 1572," he writes, "on the 9th of January when the Wixel flowed three days blood-color there happened at Thorn in Prussia about 9 o'c. at night a dreadful earthquake with a mighty storm of wind and thereupon a waterspout which swelled the stream, broke down the city wall, carried off 19 joch of bridge and drowned 300 people, hailing ten pound stones which slew many persons and burning up with a stream of fire from heaven the city of Kornhaus."[6] Thousands of tons of iron falling from miles of height upon a frozen earth must have imitated an earthquake very well.

The perfectly artificial furnace-slag-like parts of the meteoric iron at **Thorn** has of course resisted the action of the atmosphere even better than the native iron interior of the masses, but as a whole it might not require many centuries more to reduce the whole deposit to the ordinary condition of brown iron ore. This slag proves conclusively that the iron was in a fluid and oxidizing condition when it struck the earth. Beyond the rust of the oxygen of the atmosphere the mass of native iron and stone could have been only mechanically combined, but the oxygen of the atmosphere formed oxidulated and common magnetic iron which then reacted as a flux to smelt together the native iron and stone, which without this flux could not have been so smelted together, and this part of the process must have taken place upon the spot where the masses fell, for the soft slag has taken up grains of quartz from the sand upon which it fell, and even the charcoal of vegetation is visible in the masses not completely reduced to slag. The native iron shows no trace of a slaggy or porous structure but is only a little drusy, whereas the altered parts are full of pores, produced by the disengagement of air, carbonic acid

[6] In his Cosmographie Basel, 1628, lib. v. p. 1290; but Zernecke in 1727 writes that he finds no notice of this event in the Actis Thorruniensibus; see Chladni's Schrift über Feuer Meteore.

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gas, and perhaps hydrogen, and facilitating the entrance of water and the reduction of the masses to common ore.

The specific gravity of the masses is 3.8215, but in powder 5.3012, and the magnet separates the powder into 54.75 iron and 45.25 stone, the specific gravity of the iron being 7.0035 and that of the stone 2.9995. There is no sulphuret of iron in the slag mass, and only $\frac{1}{8}$ per cent in the iron mass; muriatic acid developing a slight and soon-vanishing odor of sulphuretted hydrogen; the iron itself is perfectly pure and free from all admixture, containing neither Carbon, Sulphur, Phosphorus, Chlorine, Arsenic, Lead, Copper, Nickel, Cobalt, Silicium nor any other earthy base, and only doubtful traces of Manganese. The partially altered mass contains an undeterminable percentage of Carbon and Sulphur, but a considerable quantity of Silicium. The unaltered stony part contains neither Sulphur, Boron, Phosphorus, Fluor, Chlorine, Chrome, nor any alkali, and only traces of bitter earth and the minutest quantity of oxide of manganese; and when reduced to powder its analysis was: 37.55 of Silica, 44.23 of Alumina, 17.50 of Lime, 0.53 of oxidulated iron, 0.06 oxide of manganese, 0.10 of sweet earth and 0.03 of bitter earth. Three parts of its oxygen is therefore in its sand and 4 parts in the bases; and the oxygen in the Alumina to the oxygen in the lime is as 4 to 1, forming a peculiar silicate elsewhere unknown. The slag when analyzed was found to consist of 19.05 of silica, 18.83 of Alumina, 5.44 of lime, 56.67 of oxidulated iron, and 0.01 of the three other substances above-mentioned, an accidental and variable arrangement. Of the 56.67 Ox. I. 42.51 was iron regulus, or native iron.

Another well-known fall of meteoric iron at **Schwetz** must have happened at a different time from that at Thorn for its iron is without a mixture of stone, and contains 5.77 Nickel, 1.05 Cobalt, not a trace of either of which metals can be obtained from that of Thorn.

Following up the clew which Karsten finds for us in this meteor-fall of Thorn, we reach the ground of a clear judgment upon all so-called native iron masses, that they may and therefore must be meteoric, for here are masses of pure iron certainly meteoric **without cobalt or nickel**; and here also are such masses in process of passing into red oxide of iron ore. Hence whenever a pure or native iron mass is found, by which must be carefully understood not pure iron ore, but pure iron—not pure oxide of iron whether specular or magnetic, but pure iron itself—it must be held of heavenly origin, fallen recently, and already in the process of becoming red earth. Hence the impossibility of finding meteors of pure iron embedded as fossils in the rocks of any but the most recent times.

In the Annual of scientific facts for 1856 [7] is a notice of a **report of Dr. A. A. Hayes** of Boston upon a bed of so called native iron ore, pure and malleable, used by the blacks of Liberia near Bexley, Bassa County, a specimen of which was sent to Wm. Coppinger Esq. of Philadelphia in 1853 by the Rev. Mr. Davis of Liberia, who conversed with many of the natives and was assured by them that it was ore actually broken from the rock.

Dr. Hayes' report is as follows:—The specimen had been drilled and filed when I first saw it. The filed surface arrested my attention, as the arrangement of the particles of the iron resembled that of the unalloyed part of meteoric iron, and was unlike that of any iron that had been hammered or rolled. Artificial iron is presented to us under two forms; first, that of crude or cast iron, which, always granular, is brittle, though sometimes malleable in a slight degree; second, wrought

[7] Boston 1857, p. 303.

or ductile iron, the product of refining either cast iron, or as the result of skillful reduction from an ore, in a forge fire, by alternate heating and hammering. In either case, the particles of the iron have certain definite forms, arranged as crystals in the cast iron, which are broken down and rearranged in the ductile iron, as plates, or scales, or longitudinal fibres. The native iron presents only very minute crystalline grains, which have not been broken or blended. Their color is lighter grey than that of any hammered iron. They are without much lustre, resembling iron which has been aggregated by electrical deposition. The mass is tough; and when a fragment is broken, repeated bending and doubling is required, and the fracture is hackly. The texture is not uniform. Some parts are less compact than other portions, rendering the specific gravity of the mass less than that of other iron. This inequality is due in part to the presence in the mass of crystalline quartz, magnetic oxide of iron, and a zeolite mineral, having a soda basis in part; conclusively proving that the iron has never been melted artificially. [And therefore proving quite as conclusively that it had never flowed out of the earth as a liquid mass. While its purity is equally good evidence against its sedimentary origin.] Its chemical composition is—*Pure Iron* 98.40; quartz grains, magnetic oxide, iron crystals, and zeolites 1.60.[8] There are no other metals present: a fact which prevents us from placing this iron in the class of meteorlites [unless we refer to the Thorn shower]. And the *absence of carbon* in any form removes all doubt in regard to its being possibly of artificial formation. Every form of iron which has been the subject of manufacture, contains carbon. And it is an interesting observation in this connection, that, in the large number of samples of ancient irons and those produced by semi-civilized people, which I have analyzed, not only has carbon been present, but the proportion was always larger than exists in the iron of commercial people. It appears that the rude workmen, in producing this useful metal, stop at that point where the half-refined iron is sufficiently ductile to take, under the hammer, the required form; while the purer irons are produced later in history, when the more highly prized qualities become known. [The Indian wootz however is no doubt a very ancient as it is the very best of iron.]

The evidence which has been collected respecting the locality and history of this iron tends to show that the natives of the vicinity have drawn their supplies from it for many years. Various implements are now in the United States which have undoubtedly been manufactured from native iron. Mr. Davis says, in the letter accompanying this specimen: "I am told by the natives that it is plentiful, and about three days' walk from our present residence. It is obtained by digging, and breaking rocks. It is also said to be in large lumps. In these parts, the natives buy no iron, but dig it out of the ground, or break the rocks and get it, as the case may be" The Rev. John Seys, in a letter published in the *African Repository* for June, 1851, says: "Such is the purity of the iron ore obtained by the natives of Africa in the immediate vicinity of Liberia, and which they represent as being abundant, that they have no furnaces. They need none. All their rude agricultural and warlike instruments are made by them of ore so pure that, when heated, it becomes sufficiently malleable to admit of being wrought into any shape or form. They make knives, bill-hooks, war-cutlasses, spears, axes, hoes, etc., out of this ore, without the process of smelting." Mr. James Hall, under date of July, 1855, writes: "The natives manufacture iron in quantities in the interior. It is very soft and

([8] Mr. Davis's description in 1857 noticed in Annual, p. 370, 1858, from Boston Nat. Hist. Soc. calls it a mass as large as a man's hat, craggy, cellular, part ore and of a yellow color, which well describes a meteoric mass.)

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pure. I have often been told by the beach natives who have travelled inland, that 'they take plenty wood and coal; make a big pile; put tone (stone) on him; then more wood, more coal, and more tone; then set him on fire, and burn him trong, two, three days; then iron come up.' This is the talk all along the shore; that is, the *reliable* talk. Although many say they find the pure iron, I am sure no pure iron was ever found in Liberia or its vicinity in any considerable quantity, before I left in 1840." Strictly speaking, Mr. Tracy remarks, an "ore" is a rock composed of or containing a metal in chemical combination with some other substance. "Smelting" is the reduction of a metal in an ore by the application of heat to its metallic form. A fire like that described above could never produce a heat intense enough to "smelt" any ore of iron; and besides, the result of smelting iron ore is always *cast*, and not malleable iron. But if in "breaking the rocks," the rocks should not readily yield to blows, it would be a very natural device to place it on a very hot fire. The result would be that the rock would crack into pieces and the iron would be released; and being heavier than the decrepitated stone, it might, especially if stirred a little, fall together and become welded into one mass. This, beyond all question, is the usual process in the mountainous regions south of St. John's River. Mr. Tracy further says, there is reason to suppose that native iron exists in other parts of Africa, especially the western—Adanson, a French naturalist, whose "Natural History of Senegal" was published in the latter part of the last century, asserts that the natives of that region make implements of it. A description, probably derived from him, of the native iron of Senegal, applies well to the lumps found on the "New Jersey purchase" and at False Cape. Further south and east, beyond the Niger, the Rev. J. L. Wilson found that the Pangwe people, who are gradually migrating from the inland mountains towards the coast near the equator, have "iron of their own," of superior quality, usually in "pieces about the size and somewhat in the shape of a horse-fleam, and probably produced from lumps of native iron of nearly uniform size." At Loando, about nine degrees south, the natives of the interior sell iron implements of their own manufacture for European goods, at prices less than the cost of the European iron which would be required to make them. In South Africa, the Rev. Dr. Adamson, long a missionary there, informs me, meteoric iron is abundant; but whether it has been found to be meteoric by analysis, or only presumed to be so, because all native iron has hitherto proved so, I am not informed. The existence of native iron has often been asserted. Pallas was said to have found it in Siberia, and others in South America, New Mexico, Virginia, and other regions. But all these, so far as they have been analyzed, have proved to be meteoric. The native iron of Liberia, therefore, is a substance perfectly new to the world of science and of art. Its existence in large deposits is as probable as was that of native copper before the opening of the mines on Lake Superior. Native copper had been known for ages to exist; but till the opening of those mines, it had never been found in quantities sufficient to be of much commercial importance. Now, it is found in great abundance, and some of it in masses so immense that the miners are troubled with their vastness. Whether the native iron of Liberia exists in similar abundance, can be determined only by an actual examination of the country. But if large quantities can be found at the water's edge, or even twenty-five miles inland, its commercial value must be immense.

Such is Dr Hayes' view. Certain objections have been expressed in brackets in the body of the text. The African iron could not be native because no known chemical or sedimentary precipitation would have deposited, and no volcanic pro-

cess would have ejected it in this form, nor would it have been preserved from rust in our atmosphere. If the natives of the interior knew how to make pretty pure iron (as we know they did and still do) and if this iron be not so made but actually found with rock, then iron and rock must be of meteoric origin, and the purity of the iron is no objection since the Thorn meteors are equally pure. As if to remove the only practical objection to this conclusion the following notice in the same Annual, p. 306, is accidentally appended to the report of Dr. Hayes:

NATIVE IRON OF CANAAN, CONNECTICUT.—In all the mineralogical works published during the last few years, native iron has been registered as occurring at Canaan, Conn. The authority for this statement rested on a single specimen preserved in the cabinet of Yale College. After the results of the examination of the Liberian iron by Dr. Hayes were made known, a portion of this specimen was placed in his hands by Professor Silliman for examination. Dr. Hayes has since shown in the most indubitable manner, that the Canaan iron is cast-iron, containing charcoal, plumbago, and other impurities.[9]

Even cast iron has its analogue among meteorites. to wit, in the **Niakoruak specimen** described by Forchammer, discovered by Rinck, in possession of the Esquimaux at Niakoruak, lat. 69° 25′, by whom it had been found at a short distance from their hut, on a stony flat through which the river Annorritok flows into the sea. It weighed 21 pounds. The specific gravity of the whole mass 7.00, that of small fragments varied from 7.02 to 7.07. It was so hard that it could neither be filed nor sawed, but was very brittle. Its fracture was granular; it took a high polish, and showed beautiful Widmannstätt's figures when acted upon by nitric acid. By treatment with acids it evolves sulphuretted hydrogen, (or hydrogen of bad odor) exactly like inferior cast iron. At first iron alone is dissolved, and a black matter consisting of minute crystals is left behind, which eventually dissolves, and a black powder, which proved to be carbon, floats through the fluid, while, in place of the fragment of the iron, a grey porous mass amounting to 1 or 2 per cent of the stone is left. It contained **iron,** 93.39 ; **nickel,** 1.56 ; **cobalt,** 0.25 ; **copper,** 0.45 ; **sulphur,** 0.67 ; **phosphorus,** 0.18 ; **carbon,** 1.69 ; **silicon,** 0.38 ; total, 98.57.

Besides these there are found metals of the Alumina group (with oxides soluble in caustic alkalies), of the Zirconia group (with oxides insoluble in alkalies, but precipitated from their salts by sulphate of potash), and of the Yttria group (oxides insoluble in alkalies, soluble in carbonate of ammonia, and not precipitated by sulphate of potash). The two latter groups, which have not been previously found in meteorites, form the principal part of the undissolved grey porous mass, but their quantity is so small that the author has been unable to determine with certainty what members of these groups are present. The crystalline grains, which are less soluble than the rest of the mass, consist of iron and carbon, with small quantities of sulphur and phosphorus. Although it is difficult, if not impossible, to stop the solution at the proper point, so as to insure this substance being pure, Forchammer has made two analyses, and found 11.06 and 7.23 per cent of carbon. A carbonate

[9] A stone said to have been overgrown and thus preserved in the heart of an old willow tree blighted by a storm in 1839 was presented at a meeting of the British Association by Sir Roderick Murchison, and being found to contain nickel, cobalt and manganese, was pronounced a genuine meteorite. But Dr. Percy proved it to be a piece of furnace slag like other pieces lying round the foot of the tree, containing likewise nickel, cobalt, etc. (Scien. Annual. Boston: p. 326; 1856.) This gives the positive side of the same warning not to make the presence of these metals a final proof of meteoric origin, any more than their absence a final proof of terrestrial origin.

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of iron having the formula $Fe^2 C$, would eontain 9.66 per eent of earbon, and this is probably its eonstitution. Its specific gravity is 7.172. This meteoric iron belongs to a very rare variety, and contains so large a quantity of carbon that it may be ealled meteoric east iron. That found in Greenland by Parry, as well as another speeimen mentioned by Forchammer was perfeetly malleable.[1] Parry's Esquimaux meteoric knife and harpoon are in the British Museum.[2]

Berzelius found in four **meteoric** stones traees of **tin, cobalt, copper, phosphorus, potash** and **soda.** Prof. Apjohn found in the Adair meteorite **cobalt, chrome, magnesia** and **lime** in small quantities.

The **Otumba meteorite** discovered by Rubin de Celis near Buenos Ayres in 1783 weighed about 15 tons and was eellular. The Don's imagination saw upon it impressions of gigantie human hands and feet, and those of birds, but his reason told him that no hand or foot of man or beast eould bear the toueh of the celestial metal in its semi-fluid state. He eonjectured therefore that the impressions were original to the ground on whieh it fell, without refleeting that if so the marks upon the mass must have become in basso-relievo. Sueh is the naïveté of the untrained observers of all times and lands. A piece of meteoric iron three-quarters of a ton in weight in the British Museum is supposed to be a portion of this mass. Others are there from Brazil, Mexieo, Bohemia, Saxony, the Milanese and parts of Afriea.[3]

METEORS.—"Frequent notiee is taken in the Chinese Annals of the Fall of meteoric stones. See Voy. à Peking par De Guignes, t. i. p. 195–250." (969, p. 492. Marsden's Travels of Marco Polo.)

Mr. R. P. Grey eommunicates to the Philosophical Magazine the following aceount of the fall of a large mass of meteorie iron at **Corrientes,** in South America, as given in a letter, by an observer of the phenomenon, a Mr. H. A. Symonds. He says: In 1844, I aceompanied the Corrientine army in its invasion of the provinee of Entre Rios. One morning in January, when encamped on the river Moeorita, near the Corrientine frontier, we were all awaked from a profound sleep, and every man of the army of 1,400 sprung on his feet at the same moment. An aërolite was falling. The light that aecompanied it was intense beyond description. It fell in an oblique direction, probably at an angle of about 60° with the earth, and its eourse was from east to west.

Its appearance was that of an oblongated sphere of fire, and its traek from the sky was marked by a fiery streak, gradually fading in proportion to the distanee from the mass, but as intensely luminous as itself in its immediate vicinity. The noise that accompanied it, though unlike thunder, or anything else that I have heard, was unbroken, exeeedingly loud and terrific. Its fall was accompanied by a most sensible movement of the atmosphere, which I thought at first repellent from the falling body, and afterwards it beeame something of a short whirlwind. At the same time I and my companions all agreed that we had experienced a violent eleetric shoek; but probably this sensation may have been but the effeet on our drowsy senses of the indescribably intense light and noise. The spot where it fell was about one hundred yards from the extreme right of our division, and perhaps four hundred from the place where I had been sleeping. Aeeompanied by our general (Dr. Joaquin Madauaga), I went within ten or twelve yards from it, which was as near as its heat allowed us to approaeh.

The mass appeared to be eonsiderably imbedded in the earth, which was so

[1] Poggendorff's Annalen, vol. xciii. p. 155, in Annual of Scien. Disc.

[2] Alexander, vol. i. p. 97.

[3] Alexander, p. 97.

heated that it was quite bubbling around it. Its size above the earth was perhaps a cubic yard, and its shape was somewhat spherical; it was intensely ignited and radiantly light, and in this state it continued until early dawn, when the enemy forced us to abandon it to continue our march. I may mention that, at the time of its fall, the sky above us was beautifully clear, and the stars were perhaps more than usually bright; there had been sheet lightning the previous evening.

I never afterwards had an opportunity of revisiting the Mocorita, for our permanent encampment was thirty-five leagues to the north of that pass, between which and our encampment the country was entirely depopulated by our long war; but as the spot where the aërolite fell was known to many of our subaltern officers, who were frequently sent to observe the frontier of Entre Rios, I have heard them describe it as a "piedra de fiérro;" that is, a stone of iron; and I once provided one of the most intelligent of them with a hammer in order that he might bring me a sample of it. On his return he told me it was so excessively hard that the hammer bent and was broken in unsuccessful attempts to break off a piece.[4]

Meteoric iron was discovered by two Indians twenty-two leagues southeast of **Atacama** in Chili thirty or forty years ago, and mistaken for silver, being white and soft enough to cut. Under this impression José Maria Chaile, one of them, extracted two of the masses, each weighing about 25 lbs., and buried them in a place now forgotten. The metal came afterwards into request by curiosos and by blacksmiths, and nearly all of it has been removed. The spot where the masses fell is about a league southwest of the water holes of Imilac in the heart of an arid and desolate desert, thirty leagues back from the coast, and nearly 9,000 feet above the sea level. Dr. R. A. Philippi who visited the place describes it in the second volume of the United States Astronomical Expedition, page 288. A few small pieces first dropped by the meteor were found ten minutes' walk N.N.E. of the excavations from which the Indians had removed the principal masses; tradition saying that one large one is still covered and another very great specimen had rolled perhaps when the meteor burst to the bottom of the valley. As mules are the only vehicles, none of the pieces removed could have weighed 300 lbs. unless they had been first divided. Dr. Philippi collected within a space of sixty or eighty steps long and twenty broad 673 pieces weighing altogether not quite three pounds. His two companions and his guide were equally successful and probably one-half escaped them. The meteor therefore must have rained or sparkled iron while it fell. The surface of the earth immediately around is a porphyritic sienitic clay, reddened with its own iron and mixed with an infinity of small stones like the rest of the desert; dendritic spots of manganese and amphibole occur on the desert stones which are not rolled but very angular. The meteoric fragments are also peculiarly angular; the smallest are lamellar; the larger arborescent lamellar, covered with intersecting lines, very black, some of them iridescent; having transparent olivine in small cavities, the iron looking also as if it had flowed in among olivine crystals already formed; some more compact; the olivine much decomposed to a clay showing under the microscope vitreous or crystalline grains. A fifty pound specimen in the cabinet of Don Ignacio Domeyko has polar magnetism, the poles being curiously near the two extremities. One specimen seemed the result of two fused pieces touching as they fell. Others seemed scratched or rubbed in falling. They are so delicate, so crisped, and have extremities so fine and sharp, that they must have been formed upon the spot and are undoubted meteors.

[4] Annual of Scien. Disc. Boston: 1858.

Captain Alexander found a considerable a ea on the east bank of the **Great Fish river** covered with masses of malleable iron, too numerous to be imagined aërolites until J. Herschel found 4.61 nickel in a specimen brought home.[5]

Ainsworth recounts in his Researches [6] how boulders of malleable iron occur in the Valley of Ekmáh Chei and on the plain of Divriji in **Armenia,** but gives no description by which their meteoric origin can be demónstrated.

Similar masses of meteoric iron in a cañon near **Tucson** in New Mexico, two of which were used as anvils by the blacksmiths of the village.[7] Mr. Bartlett U. S. Boundary Commissioner described one of these masses as weighing 600 pounds and Dr. J. L. Smith gave as its analysis: nickeliferous iron 93.18, chrome iron, 0.49, Shreibersite 0.84, olivine 5.06.[8]

A much larger mass weighing 3,854 lbs. exists in **Chihuahua,** Mexico. Another weighing 252 lbs. found at **Saltillo,** Coahuila in Mexico, has been deposited in the Cabinet of the Smithsonian Institution at Washington and was described before the American Association meeting there in 1854, by Dr. Smith, who evidently sustained the lunar theory which assigns the origin of such masses to the body of the moon, from which when ejected forcibly enough they might revolve for ages round the earth before they reached its surface. Laplace and Arago once held this theory but gave it up in favor of their genesis from shooting stars. The facts that one-twentieth of the surface of the moon is volcanic, that its attractive energy is but one-sixth of the earth's, that it has neither atmosphere nor ocean to oxidize its iron, which would therefore reach us pure, are the principal arguments in favor of this theory.[9]

Chladni draws attention to another exhibition of this kind in the Mexican province of **Durango,** which Alexander von Humboldt calculated to weigh from 15 to 20 tons, and contained nickel. Humboldt himself in the Cosmos speaks of the mass that struck the pyramid of Cholulu and was worshipped by the priests.

In 1835 at **Cirencester** England a stone weighing 9,270 grains rushed through the air without light, passed some workman seated against the wall and struck through a haystack upon the earth with a great shock ; when picked up it was not hot ; contained much iron but was not magnetic. Half a mile south of it a multitude of smaller pieces fell in a shower.[1]

Among the **latest meteoric masses** seen to fall and found are two described by M. Hornes before the Imperial Academy of Vienna ; the first fell the 15th April 1857 at Kaba near Debriczen, at 10 o'clock in the evening, with great noise and a sweeping glare which lasted 40 seconds and was discovered the next morning buried in the road as a blackish stone, weighing 8 lbs. highly magnetic, botryoidal and containing fragments of sulphuret of iron. The other fell October 10th 1857 near Kalsbourg about midnight, deafening a priest Nicolas Maldowan with its explosion and roar, and was found next morning half buried in a vineyard, a pyramidal mass of 34 lbs. weight, specific gravity 3.11, full of grains of olivine, native iron, and magnetic oxide. An analysis by Buckeisen showed it composed chiefly of olivine, augite, iron and sulphuret of iron.[2]

In Cocke county **Tennessee** Professor Troost in 1840 found many pieces of meteoric iron in the hands of people who attached an incredible value to them, sup-

[5] London and Ed. Phil. Mag. xiv. 32, in Karsten's Memoir.

[6] London, 1838, p. 285, in eodem.

[7] Annual of Sci. Disc. 1852. Report of Dr. Leconte's communication to Albany meeting Amer. Assoc. 1851.

[8] Annual Sci. Enq.

[9] Paper not published in the proceedings but reported in the Annual of Sci. Dis. 1855

[1] Brit. Assoc., 1857, p. 140.

[2] Cosmos de Paris, 1858, p. 572.

posing them to be of silver. The principal mass must have weighed originally about 2,000 lbs., and was composed of metallic iron (iron 87. nickel 12. carbon 0.5), graphite (carbon 93. iron 6.) pyrites and brown and yellow hydroxide of iron. Ninety-five hundredths of the whole was nickeliferous iron, partly crystalline in lamellæ, and partly agglutinated in grains; malleable; harder and whiter than common wrought iron, and filing white. The pyrites was softer than the common sulphuret of iron and of great quantity. The hydroxide occupied the whole surface of the mass. Other smaller masses were found in Dickson Co. and on Caney Fork in Tennessee, and several in N. Carolina twenty miles east of the Warm Springs.

A mass of 55 pounds' weight was ploughed up in Tazewell county **Tennessee,**[3] composed of iron 83. and nickel 14.62 with small proportions of copper, cobalt, phosphorus, chlorine, silica, sulphur and magnesia, and some small particles of phosphuret of iron and nickel called schreibersite resembling pyrites. On earth phosphates are numerous and abundant, but no phosphuret is known. It exists in plates and fragments visible to the naked eye in almost all meteoric iron. From Trinity river, Louisiana, a mass of over 3,000 lbs. was sent to New York and described by Silliman.[4]

A meteorite, weighing 178 lbs. from Great Lion river Nemaqualand **South Africa,** and another weighing 58 lbs. from Newberry **South Carolina** were added to Prof. Sheppard's collection at Amherst in 1852.[5] The same year Prof. Root describes in Silliman's Journal a drop-shaped mass weighing 9 lbs. found in digging a ditch on the Seneca river in New York.[6] Whether this was of ante-historic date or not is not stated, and it has been recently affirmed and even made a matter of admiration that no fossil meteoric iron has ever been found. But it is well known that the hardest iron ore outcrop weathers by accepting oxygen, and that no isolated mass of *purer* iron could be buried in moist sand or clay through the latest or shortest geological era without becoming a mass of rust, and probably disappearing by solution. At any rate a mass of meteoric iron was discovered in a railroad cutting in the spring of 1850 near Schwetz upon the Vistula, buried four feet beneath the surface of sand, lying upon the subincumbent clay, 9 in. long and weighing 43 lbs. Its outer surface was rounded and coated with hydrated oxide. On polishing a section, Widmannstättian figures were obtained with acid, and nickel by analysis.[7]

Meteoric iron, Wöhler states, according to his observation in the majority of cases is **in the passive state,** or cannot extract copper to coat itself withal from a solution of the neutral sulphate of copper; but strange to say the power to do this is instantly communicated to it by touching it while in the solution with a piece of common iron, or by adding a drop of acid to the solution. But if the film be filed away the new meteoric surface is again found to be passive in the solution; the power is but temporary. This inertness is not due to any action of nitric acid previously applied to bring out the Widmannstättian figures, but characterizes new masses. Not all however; some genuine meteors are active; six in fact out of seventeen examined; and four more gradually became active showing action at first at one point or at the margins of the fluid. An artificial alloy of iron and nickel (which damasked on corrosion) was found to be as active in sul. cop. as common iron.[8]

[3] Described by Dr. J. L. Smith in Silliman's Journal. [4] Journal, vol. iii. p. 45.

[5] In the May number of Silliman's Journal for 1855 is a memoir on meteorites by Prof. J. L. Smith giving figures and analyses of 5 North American specimens.

[6] Ann. Sci. Dis. Boston, 1853, p. 300. [7] M. S. Rose, Berlin Acad. 1851, Ann. Sci. Dis. 1852. [8] Ann. Sci. Dis. 1853, quoting Poggend. Ann.

PRIMARY.

CHAPTER I.

THE PRIMARY IRON ORES.

In Professor Whitney's admirable treatise on the metals of the United States,[1] a work of equal judgment and learning, and written in a style at once scholarly and practical, the author states the several theories entertained of metallic veins. He dismisses summarily and with evident contempt the **first theory** he mentions, to wit, that they are contemporaneous deposits with the rocks through which they run. He rejects the **second,** to wit, that they are fillings from below of open fissures in the crust with molten metalliferous matter for three reasons, 1. because they differ in the same neighborhood when they cut different rocks; 2. because their walls show no traces of the action of that incredible force which alone could force them to the surface; 3. because the heavier metals would in that case occupy the lower and light metals the higher parts, which is never the case.[2] To the **third theory** he yields a limited

[1] The Metallic Wealth of the United States described and compared with that of other Countries, by J. D. Whitney. Philadelphia: Lippincott, Grambo & Co. London: Trübner & Co. 1854, p. 60.

[2] Yet Mr. Whitney seems to adopt this theory in the communication which he made to the American Association at the Providence meeting, where he remarked that there were scattered over the earth deposits of iron of peculiar character and extraordinary purity, and that the mode of their occurrence was also peculiar; they belonged to certain systems of rocks, and were found only in those systems. The principal localities in which this iron occurred were Scandinavia, northern New York, Superior and Missouri. In Sweden there was a single bed 700 feet in width by four or five miles in length. The deposits in northern New York were not so extensive, but the Cleveland Iron Mountain in the Lake Superior country rose to the height of 1,039 feet above the lake, with a breadth of 1,000 feet, and was entirely composed of iron ore. Along its summit were numerous knobs 50 to 100 feet in height, which were perfectly pure. There were numerous other mountains in Missouri which furnished equally pure ores. The ores thus found were almost always of two kinds, specular and magnetic. The specular predominated in Sweden, Superior and Missouri, while the magnetic prevailed in northern New York. In Superior the iron beds lay between trap and talcose slate; in Missouri porphyry was near; in New York it seemed to have been sedimentarily deposited in lenticular masses, and afterwards subjected to metamorphic action; these all in azoic rocks. As the azoic periods were more violent in their action than later periods, *it was probable that what was thrown up during those periods came from a deeper portion of the earth*, and we might hence infer that there were great deposits of pure iron deep down in the earth.—*Reported in the Annual Sci. Facts*, 1856, p. 303.

assent, to wit, that *some* metalliferous deposits were sublimed from the hot nucleus of the planet, and therefore if not the consequence of molten ejections, are due to a still hotter cause, but states that the objections to this theory are the same that avail against the one preceding it. He rejects the **Wernerian theory** of chemical solution and deposition in open fissures from above, 1. because we can conceive of no reason for a solution covering the surface not *coating the surface* as well as filling the fissure; 2. because we find no mechanical or common stratified rock deposit in the fissures, but on the contrary the arrangement of every vein in sheets against the walls; and for many other reasons which he says it is needless to specify. The **fifth theory** of **lateral secretion** therefore he adopts, and considers it most widely entertained at present among geologists. It conceives of a process due to various causes and requiring a long period of time but consisting chiefly in the secretion or segregation of metals in veins by solution from the rocks on each side, and their deposition upon the walls under the influence of electro-chemical forces.

No doubt multitudes of metal veins were thus formed, in fissures kept like natural vats or galvanic batteries always full of acidulated waters acting on the porous rock material of the walls, dissolving out the various metallic ingredients therein originally deposited and precipitating these in successive layers against the surface of the walls. But it is impossible to arrange the innumerable facts of the world of veins under this or any other one head, or explain them by this or any other single theory. There are certainly veins of recent infiltration; but there are others which as evidently were original beds. These last Mr. Whitney would distinguish as *false veins* from the true veins of which he speaks. But **veins** and **beds**, distinguishable as they are in the majority of cases, nevertheless so graduate into each other as to show either a mixed or a doubtful origin. This is peculiarly true of the so-called veins of primary iron ore; and the first theory which Mr. Whitney so summarily dismisses as opposed to all known facts, is in certain principal localities the only one which apparently embraces all the facts. The so-called *veins* of specular and magnetic ore in northern New York, New Jersey and Missouri are of this class and when Mr. Whitney says that "the mountain masses of

Missouri have preëminently an eruptive character and are associated with rocks which have always been considered as of unmistakably eruptive origin,"[3] we must interpret the expression by the preceding and succeeding paragraphs, as the judgment of the past and not his own, saying that the specular and magnetic ores of Lake Superior, New York and Scandinavia fall into the same category and yet are not true veins but "slaty beds impregnated with peroxide of iron,"—"exhibiting the appearance of a secondary action having taken place since their original formation."

"The masses of ore in the azoic,[4] though developed on a larger scale, and made up of purer ores than those occupying any other geological position, are not economically so important as those which occur in stratified deposits in connection with the coal. The ores found in this group are the oxides, specular ore and magnetic ore. When associated with foreign matter, this is almost invariably of a silicious nature, quartz in some form; but they are generally quite pure, often approaching a state of chemical purity.[5] They are particularly valuable as being more likely than any other ores to be free from arsenic, phosphorus and sulphur, which have an injurious effect on the quality of iron.

"The ores of Sweden and Norway, which furnish so large a portion of the iron used for conversion into the finer qualities of steel, belong chiefly to this class of deposits.

"The following scheme of their mode of occurrence is given by Durocher, who has published a very detailed and careful description of the metalliferous deposits of Scandinavia:

DIVISION I. Deposits in the Azoic system (gneiss and argillaceous shales).	A. Deposits of pure magnetic oxide.	*a.* In gneiss alone or accompanied by granite and in the allied slates, talcose, chloritic and micaceous.
		b. In Hornblende rocks intercalated in the gneiss.
	B. Specular iron, pure or mixed with mag: I.	In gneiss and associated quartzose and micaceous slates.
	C. Magnetic oxide in the argillaceous shales.	

"The remaining ores, which are comparatively of little importance, consist of masses of magnetic and rarely of specular ore, near the contact of the palæozoic rocks and the granite,[6] and bog ore, forming deposits in low ground and swamps.

"The azoic series in Sweden and Norway is made up principally of a crystalline, granitic gneiss, presenting an almost infinite succession of feldspathic, quartzose, micaceous and hornblendic laminæ, and often cut through and disturbed by dykes of greenstone and granite. The researches of Murchison and Verneuil show con-

[3] Metallic Wealth, p. 433.

[4] [By Azoic rocks are meant those which lie underneath the lowest rock containing fossil shells, plants or worm tracks.—J. P. L.] [5] [That is nearly pure oxide.—J. P. L.]

[6] [Such as the Cornwall mine in Lebanon county Pennsylvania, and others in Berks county in the same range.—J. P. L.]

clusively that these rocks had taken their present form before the deposition of the Lower Silurian strata. There are several localities where the magnetic oxide occurs nearly pure and without gangue. Of this the mine of Bispberg furnishes a good example. It has the form of a lenticular mass, and its longest axis coincides with the direction of the schistose structure of the slates in which it is inclosed. The mines of Danemora are in a ferriferous band of about 600 feet in width and 7,000 in length. In the neighborhood, gneiss is the prevailing rock; but in the immediate proximity of the mines, the rock exposed is a greyish limestone, slightly magnesian, accompanied by talcose and chloritic slates, which probably are subordinate to the gneiss. The deposits of iron form imperfectly cylindrical masses, with their axes nearly vertical, and their bases much elongated in the direction of the schistose structure of the rock.

"The mines of Utö, which are especially interesting to the mineralogist on account of the variety of minerals containing lithia which are found there, are of considerable importance. The ore is principally the specular oxide mixed with the magnetic. It is in the form of lenticular masses inclosed in micaceous slates and quartz rock. At the point of contact of the ferriferous mass, the quartzose beds predominate, and the silica is often impregnated with and colored by the iron. The principal deposit is about one hundred and twenty feet across its widest part, forming an enormous lenticular mass, of an irregular contour, and with a vertical axis.

"At Gellivara the magnetic oxide forms a mountain mass three or four miles in length and a mile and a half in width, a great portion of which is very pure, some parts of it containing specular ore mixed with magnetic. The principal reasons why this enormous mass has not been worked to any considerable extent are its remoteness from navigable waters and its very high northern latitude (67°).

"These deposits are called, in Sweden and Norway, veins, but they differ materially in character from what is generally understood by true veins. With a few exceptions, they appear to have been deposited in the midst of schistose or massive rocks, in forms which approach more nearly to beds or elongated bands and irregular masses; and they have evidently not filled previously existing fissures which cross the strata at an angle, but almost uniformly coincide, in the direction of their greatest elongation, with the strata of the schistose rock.

"The micaceous specular ores are generally associated with the quartzose and mica slates, and but rarely with the calcareous rocks. When there is calcareous matter near the junction of the ore and the inclosing rock, there is a great variety of minerals in the gangue, indicating that they were formed under certain conditions by the metamorphic action of the ferriferous mass upon the adjacent rocks. The mine of Hassel, in Norway, offers a good instance of the tendency of the specular ore to associate itself with the quartzose and slaty rocks. The deposit is not a vein, but rather a series of slaty beds, impregnated with peroxide of iron to the amount of twenty or thirty per cent.

"There can be no finer instances of the mode of occurrence now under discussion than are to be found in this country. The mountain masses of Missouri have preëminently the eruptive character, and are associated with rocks which have always been considered as of unmistakably eruptive origin. The iron region of Lake Superior, which is even more extensive and more abundant in ores than that of Missouri, is another instance of the vast development of these ores in the azoic.

"In the State of New York, in the same geological position, we find the same occurrence of the specular and magnetic oxides, and almost rivalling with those of the regions just mentioned in magnitude and importance. Here, however, the evi-

dences of direct eruptive origin are perhaps less conspicuous, and the deposits seem, in many cases at least, to exhibit the appearance of a secondary action having taken place since their original formation. In this region, these ores have in their mode of occurrence the most striking analogy with those of Scandinavia. Like them, they generally coincide in the direction of their greatest development with the line of strike of the rocks in which they are inclosed, forming lenticular or flattened cylinder-shaped masses intercalated in the formation. The inclosing rocks are similar in character to those of Sweden; they are gneiss, quartzose, and hypersthenic rocks. The deposits of these ores will be noticed more particularly farther on, under the head of each State.

"Although the iron ores of the azoic have not always had a purely igneous origin, yet even in those cases where they bear the most evident marks of having been deposited in beds parallel with the formation, with the presence of water, we must acknowledge that preëxisting eruptive masses may have furnished the material from which they were derived. That the azoic period was one of long-continued and violent action cannot be doubted, and while the deposition of the stratified beds was going on, volcanic agencies, combined with powerful currents, may have abraded and swept away portions of the erupted ferriferous masses, rearranging their particles and depositing them again in the depressions of the strata. This seems the most probable origin of some of these lenticular beds of ore parallel with the stratification, where it is difficult to conceive of a fissure always coinciding with the line of strike of the formation, and where the mechanical evidences are wanting of the thrusting up of such masses of matter, which we know could not have taken place without many dislocations of the surrounding rocks which would have made themselves very apparent.

"The masses of iron ore in the azoic are far more grand in their scale of development than in any other formation, characterizing it everywhere as the age of iron; a fact which has a high degree of significance, when we consider that this is the oldest geological formation, and that we thus, as it were, receive a hint as to the structure of the interior of the earth. In this connection, it will be remembered that the bodies of extra-terrestrial origin which fall upon the earth, or meteorites, are very often found to consist of metallic iron, and we are thus led directly to infer the existence of vast masses of metallic iron within the interior of the globe.

"The evidences of eruptive masses of iron ore grow fainter as we ascend in the scale of formations, or recede from the focus of internal heat; but, nevertheless, the ferriferous emanations from volcanoes still in action, as well as the undeniable upheaval of oxidized iron from the interior of the earth during comparatively recent periods, show that there are still supplies of the same material accessible, which are not below the depth at which chemical action is still going on and making itself sensible."

It appears from the foregoing that Mr. Whitney accepts both the eruptive and the sedimentary theories of the formation of the primary iron ores and applies the former to unknown, invisible masses antecedent to and now deeply buried under all, even the oldest rocks which appear upon the present surface; masses of far greater size and depth than the greatest yet discovered, proportionate to the greater scale of all volcanic action in that pre-azoic day, and offering their sides and tops to such

erosion and solution as would of course happen in such unsettled times, and be sufficient for producing the vast sediments of iron which have been taken for volcanic outbursts of the molten metal. But there is a fatal difficulty in the way of this hypothesis. These ore beds are not *breccias*. Deposits of the kind imagined would be *conglomeritic;* blocks of pig iron would be seen scattered through strata of granite. The hypothesis halts precisely where a similar sedimentary hypothesis for the origin of coal halts; it is unable to explain the solid homogeneous outspread and evidently local character of the deposit. But setting this aside, it is a mere hypothesis. No such masses of cast iron have ever been seen in the world. The beautiful theory of Sir Humphrey Davy so charmingly explained and illustrated by Sir Charles Lyell in the xxxiii. chapter of his Principles, according to which the metallic bases exist in purity in the molten nucleus of the earth, and at the crust are alternately oxidized and deoxidized by the oxygen and hydrogen of the sea water and the air, giving rise to steam pressure, earthquakes, volcanic lavas, pumice dust and gaseous exhalations, is perfect in its way; but it does not help us to conclude that planetary masses of pure iron have ever been ejected through the crust. Mr. Whitney however adduces what he thinks are positive examples of this kind of action in more recent days to support the ejection theory. He says:

"The magnetic iron ore hill near Nijny Tagilsk, which is extensively wrought, affords a fine illustration of an eruptive mass in the midst of sedimentary formations. There are numerous points of eruptive rocks, mostly hornblendic greenstone, among stratified masses, which have been highly metamorphosed in their vicinity. The age of the sedimentary beds is referred by Murchison to the Upper Silurian, although the fossils are mostly obliterated by the metamorphic action. These limestones appear to have been rent in twain by a narrow ridge of intrusive greenstone, which rises to the north of Nijny Tagilsk into a high hill (Vissokaya-gora), on the summit and flanks of which iron ore has long been extracted. The chief mass of the ore is seen to occupy the valley on the western side of the hill, where it has been deeply cut into by open quarries, and is found to consist of an enormous body of ore, rudely bedded and traversed by numerous joints, and exposed for a height of a hundred feet and a length of several hundred. In opening out the side of the valley nearest to the hill of greenstone, irregular knobs or points of rocks were met with, on stripping which it was found that the iron ore had accommodated itself to the irregularities of their surface, and that at such points of contact, the ore was not only harder and more crystalline than usual, but also much more magnetic than at a short distance from the greenstone.

"The rock associated with the magnetic iron ore of Mount Blagodat, near Kuschwinsk, which has been worked since 1730, is a feldspathic augite porphyry. So far

as they have been worked down, the excavations exhibit a continuous mass of fine-grained magnetic iron ore, with flakes of yellow and pink feldspar and brown mica. It is the opinion of Col. Helmersen, who has carefully studied this locality, that these feldspathic iron-stone masses are portions of dykes of eruptive character which have traversed the porphyry, a fragment of that rock even having been found in one of them which rises up from near the base of the hill.

"The Katschkanar, one of the loftiest and most rugged summits of the Ural, is made up of igneous rocks (greenstone), having a bedded structure and traversed by regular joints, so as to give it the appearance of a sedimentary rock; it is cut through by courses of magnetic iron ore, and has an abundance of the same substance diffused through it in crystals; but the ore is hard and intractable, and being at one of the most inaccessible points of the Ural, the works which were commenced there are now abandoned.

"There can be no doubt, from the consideration of all the phenomena of these localities, that the ores are of purely eruptive origin, and that they have played the same part as the igneous greenstones and porphyries with which they are associated. At Nijny Tagilsk, it is evident that the magnetic iron penetrated the preëxisting greenstone, and flowed, as sub-marine lava or volcanic mud, into the contiguous depressions. This is proved by the fact that the ore expands in width, thickness, and dimensions, as it is traced into the lower parts of the valley, precisely as a lava stream which fills up the sinuosities of the subjacent rock. Such was the opinion of Helmersen, and it was adopted by Murchison, although not agreeing with his preconceived theories.

"The iron mines of Elba, which are celebrated alike for the length of time they have been worked and for the purity and beauty of their ores, furnish another interesting example of the class of eruptive masses associated with the more modern rocks. The metalliferous deposits of the island are mostly concentrated towards its eastern extremity, and are associated with serpentine. The sedimentary rocks in that vicinity have been metamorphosed and intermingled with serpentine, so as to give rise to an abundance of beautifully variegated marble. The mass of specular ore worked near Rio is included between the upturned slates which form the flank of the Mountains of St. Catherine. It has all the appearance of having been forced from below upwards through the strata, which are highly metamorphosed at the contact of the ferriferous mass, and into which the metallic emanations have penetrated in every direction. As a proof of this, it may be observed that the attendant minerals vary with the adjacent strata. In the quartzose slates, crystallized quartz predominates; in the calcareous strata, actinolite and yenite have been developed.

"The mass of magnetic ore and hematite of Monte Calamita is more extensive than that of Rio, and exhibits even more clearly the phenomena of igneous action. It has uplifted the superincumbent strata, and produced on them all the effects of metamorphism due to igneous action. For instance, the compact limestone which lies adjacent to the ferriferous mass is changed into a saccharoidal dolomite, and along the line of contact silicates of lime, magnesia, and iron have been developed. According to Burat, the whole appearance of the mass is that of an immense wedge driven upwards from below into the calcareous and schistose rocks, producing all the effects to be expected from the intrusion of such a mass by igneous agency.

"The geological age of the strata which have been thus metamorphosed by the ferriferous masses, is considered by Burat to be near the Jurassic, but the introduction of the metallic matter itself probably took place at a much later period, perhaps after the deposition of the calk."

When we remember how many observers have pronounced the Missouri iron mountains solid masses of pure metal rising from the central regions of the earth in the shape of cones, thrusting their points through the crust precisely as men described the Maunch Chunk summit mine before the floor of that immense horizontal bed of coal was discovered and its shape revealed,—we may withhold for a while our unqualified assent to these descriptions and suspect that future research may modify the appearances presented now. But even if they still continued to be well adjudged expressions of the possibility of volcanic iron they will not cease to be rare exceptions to the general rule, and therefore supporters only to that extent of the ejection theory. They will still leave the sedimentary theory all the ground it asks for innumerable beds of crystallized iron in metamorphic rocks; original productions at the bottom of a sea; not subsequent segregations in fissures, such as Prof. Whitney goes on to describe:—

"Deposits of this class are widely scattered over the world, and frequently developed on a grand scale, though not so much so as those in the azoic. The more extensively metamorphosed the formation, and the older it is, the more do the deposits of iron ore take on the character of true veins. The spathic ore is one of the most abundant in this position, forming often veins of great extent, and furnishing large quantities of a material eminently calculated for making good iron and steel. The interesting vein of this ore at Roxbury, Connecticut, may be noticed as a good example of the class. Veins and vein-like masses of the same ore, and similar in position, occurring in the valley of the Rhine, furnish the material to the numerous manufactories of steel of that region.

"Veins of magnetic iron ore are also frequently found occurring in this position. In this country they are especially numerous. They are generally segregated masses lying in the direction of the stratification. Sometimes they are quite pure, being mixed only with a little silicious matter; at other times they are associated with other metalliferous minerals. Occasionally the iron ore is found, as the depth increases, to be replaced in part by ores of copper. In the southern States, the occurrence of gold with ores of iron is very frequent, but the latter are too much mixed with pyrites to be of any value apart from the gold which they contain.

"In the carboniferous limestone of England there are numerous deposits of hematite of great importance, some of which are intermediate in character between veins and beds, while others appear to occupy previously-formed fissures, and to belong to the class of gash-veins, the ferriferous matter having been deposited in them from above. In general, the kind of ore-deposits now under consideration, when not associated with crystalline rocks, are not distinctly marked in their characters, but seem to form a connecting link between the stratified and unstratified masses."

It is not intended to deny that iron is involved in all volcanic operations, with silica, alumina, lime, magnesia and other

metallic oxides and non-metallic elements. On the contrary; no element is more universally present in the world, and therefore none can suffer a greater variety of contingencies and transformations. Iron appeared in the lavas of Etna during the eruption of 1855 in two forms the magnetic and the non-magnetic. The early lavas of that eruption were grey, much more crystalline and strongly magnetic. The later lavas were dark, with a glassy coating, and had no action upon the magnet. Both were found to contain nearly the same amount of iron. Both contained also phosphoric acid (1.4 and 2.2 per cent).[7] But there is need of some strong counteracting prejudice in favor of a truer view of the primary so-called *veins* of iron against the old prejudice that every unexplainable appearance among stratified rocks must be an issue of red-hot or fluid mineral from some conjectural reservoir of volcanism underlying even the quietest portions of the earth-crust, a prejudice which lies at the bottom of men's credulity to the cunning miner's maxim "it will improve as you go down." Mineral like vegetable life to a remarkable extent confines itself to the mere surface of the planet.

All iron ores in gangues and layers, says Gustav Bischof[8] are either immediate deposits from waters or are deposited from such by the removal of other substances. There is no rock sediment in fact wholly free from protoxide of iron. Even in the variegated red sandstones I have found remarkable quantities. Plenty of material is at hand therefore in the adjoining strata for even such vast beds as those of Schlettenbach and Bergzabern in Rheinbaiern.[9] Should a rock contain nothing but peroxide, organic substances will reduce this to protoxide and the developing carbonic acid will convert this again into carbonate of iron. Never has an iron gangue been filled by sublimation. The sublimation of iron in Vesuvius is a local exhibition, impossible, as Mitscherlich showed,[1] without the help of water. Iron ores change into each other, but never into other minerals. All of them are products of the decomposition of iron-holding minerals, and as scarcely any mineral is not iron-holding any mineral may form an iron ore bed. Iron ores are replaced by Quartz, Hornstone, Graphite, Psilomelan and Chlorite.

Bischof gives instances of curious apparent changes of magnetic iron and other iron ores both crystallized and amorphous into each of these minerals: to wit, Quartz in the form of iron, spathic, specular and pyrites, vol. ii. page 1260; Hornstone page 1305; Graphite as lately discovered in the form of iron pyrites in the Haidinger's meteoric mass of Arva, described in the *Wiener Zeitung* of April 17, 1844, on page 70; Psilomelan in the form of arseniate of iron, on page 1325; and Chlorite in the form of magnetic iron, etc., on page 1327.

[7] Deville, Leblanc and Sewy, in Annual Sci. Disc. Boston, 1858.

[8] Lehrbuch der Chemischen und Physicalischen Geologie, Bonn, 1854, vol. ii. p. 1325.

[9] V. Leonhard n. Jahrb. 1845 S. 1 ff.

[1] Poggend. Ann. B. xv. S. 630.

On the other hand we know of 26 minerals which are replaced by iron, that is, in the forms or moulds of which it casts itself by percolation and crystallization. In springs, rivers and seas the carbonate of the protoxide and the sulphate of iron occur, the latter seldom, the former in all waters with scarcely an exception, and hence the multitude of crystal forms which its universal precipitation enables it to possess itself of, for we are not to imagine the peroxide or the hydrated peroxide or the sulphuret to be ever in solution in water,[2] except in so far as the double carbonate alkalies dissolve the hydrated peroxide, which therefore in many cases can replace and be replaced.

Bischof then gives in a series of paragraphs from pages 1328 to 1363 the pseudomorphs of the iron ores according to the following forms: spathic iron, brown ore, peroxide, pyrites and white pyrites in the form of **calc-spar**;—spathic iron, brown ore and stilpnosiderite as **bitter-spar** (carbonate of magnesia);—stilpnosiderite as **zinc-spar** (carbonate);—spathic iron, brown ore and pyrites, as **baryta-spar**;—brown ore as **gypsum**;—brown ore and red ore, as **fluor-spar** (fluate of lime);—brown ore and pyrites, as **quartz**;—brown ore as **blend** and **galena** (sulphuret of zinc and lead)—brown ore as **carbonate of the oxide of lead**, as pyromorphite **(phosphate of lead)** and **red copper** ore;—pyrites and white iron pyrites as schwartzgültigerz **(sulphuret manganese?)** and rothgültigerz **(red silver**, sulphuret of antimony and silver);—brown ore as **comptonite** (hydrated silicate of alumina and lime);—brown ore red oxide and magnetic ore as **spathic iron**; brown ore as **ankerite** (triple carb. lime, mag. iron);—red oxide as **brown ore**;—brown ore as **arseniate of iron** and as skorodite **(cupreous arseniate of iron)**; red oxide as arseniate of iron; stilpnosiderite as **sparry blue iron** (krokodilite, a soda silicate of the protoxide of iron);—brown ore as **pyrites** and **white iron pyrites**; red oxide as pyrites;—pyrites as **magnetic ore** and as **arsenical pyrites**. In these sections lie the explanations of all the changes of appearance which distract the subject of the original deposit of iron ores. Each of these minerals have been dissolved away like so many fossils and these various iron ores have taken their place and form. Every member of this range of transmutations seems to be both beginning and end. If in the majority of cases the carbonate protoxide is the first precipitation of the waters, from which the hydrated peroxide, protoperoxide and peroxide proceed, yet these oxides may in a reversed order by partial reduction through organic substances become carbonate protoxide It is a circle which may often repeat itself, and it is clear that the same forms may be at different times reproduced. Breithaupt instances the fresh Lobenstein spathic iron coming from pseudomorphic brown ore; the second spathic iron must have been formed inside after the first had already been exchanged.

No metamorphoses of pyrites or magnetic pyrites as spathic iron, brown ore or red oxide are known. Either these last cannot change to sulphuret of iron, or the earlier forms must become lost and the pyrites crystallize after its own form. The yellow pyrites mentioned in vol. i. page 917–922 was produced entirely from solutions of the salts of iron and mostly from acid carbonate of protoxide.[3] The yellow pyrites in stone coal and brown coal has been precipitated from waters holding a carbonate of iron in solution, the organic matter here being abundant to

[2] Compare page 1152+.

[3] Breithaupt instances the miner who fell down the deep mine at Fahlun, Sweden, and was found 60 years afterwards entirely converted to yellow pyrites, but after being kept for seven years in the museum of the works, became sulphate of iron and crumbled away. The agent here was of course a solution of a salt of iron.

make the acid and reduce the peroxide. The yellow pyrites replacing calc-spar, baryta-spar, quartz, etc. (add the white iron pyrites replacing fluor-spar) furnish further evidence of this origin from solution. According to Forchhammer, however, ferruginous clay in contact with decaying sea-weed makes pyrites direct, although even here the formation may be preceded by the dissolution of protoxide iron in carbonated water.[4]

The boldness with which Bischof, looking from the windows of his laboratory with the eyes of a chemist, out upon the primary mountains of the world, denounces the old plutonian standpoint and overturns all the settled conclusions of geologists, is difficult to imitate and even to admire. Yet he only does what the whole tendency of recent structural as well as chemical discovery has been predicting that it must be done. In fact the question has shaped itself to one of limitation merely, and the chemist who can show to a demonstration how still another plutonic rock has probably been formed in the wet way becomes the leader by being so much nearer to the inevitable end. Bischof's own words must be given therefore to justify him in the eyes of those who pronounce him a dangerous heresiarch in chemical geology.

From the foregoing investigations comes the important result that **augite** [or *pyroxene*, a combination of silica, lime, protoxide of iron and sometimes manganese and alumina in many varieties] can be **changed into** not merely *hornblende* (page 532) but *garnet and hornblende and* **magnetic iron**, and that therefore these three fossil-rocks [Fossilien] can form themselves by processes of exchange. As described above these Umwandlungs-processe have gone on at *Arendal* on a magnificent scale; as *Weibye* relates, in describing the Thorbjörnsbo mine, which in 1842 was 180 feet long, 48 wide and 120 deep, and in which the ore was intimately mixed with granular red garnet and augite or hornblende, the mixture occurring in isolated fragments, sometimes enveloped by, sometimes enveloping magnetic iron, and sometimes both together dissolved away [verfliesst]. These ore masses have most commonly well defined edges where they touch the inclosing rock masses whether these be granitic or syenitic, or a various fossil grouping of garnet, mica, kokkolith, etc.—a rind as it were of ironstone; but sometimes they branch off into, and sometimes flow in together with the wall rocks. The greater number of observed syenitic walls inclose either bed-like ironstone masses with many outrunnings, or else ironstone kidneys. The greater number of observed granitic walls inclose irregular masses (segregations) and seldom form true veins. None of either the veins or the segregations show disturbing action upon the neighboring rock. Many observations have convinced Weibye that the vein masses inclose but few small and immature fossil-rocks; these are best developed in the segregations, which in granite are wholly irregular—great and small, with and without ramifications—and never disturb the strata or change the character of the stone. He makes no hypothesis; enough that these irregular masses have impressed it upon him that

[4] Bischof, vol. ii. p. 1364.

they must have been separated from the rock. Not only at Arendal but elsewhere meets us the phenomenon of a **change of augite into magnetic iron.**

Then follow descriptions of the magnetic ores of the Ural, Hartzgebirg and Türingenwald, "exhibiting as a fact that it is a segregation from augite, and evidently also from allied fosil rocks. Can one imagine now a plutonic or any other than a wet way by which such segregation may come about?"

The oxide and especially the protoxide of iron are strong bases closely related to and easily with moderate heat uniting with silicic acid, as is seen in blast furnace processes, when for instance copper smelters add quartz minerals to get a fluid slag from the protoxide of iron and silica, or when welders sprinkle fine sand on the end of the iron to be welded to turn thereby the coating of proto-peroxide into a silicate slag which every blow of the sledge removes and lets the pure iron come face to face. See then from these examples how impossible it would be to find quartz and magnetic iron separate if they were of igneous origin. Yet at Arendal the ramifications of magnetic iron penetrate the syenite and granite walls, while bands and veins swarm along the bed-planes and cleavage lines of the gneiss. As little can the magnetic ore result from a metamorphosis of the gneiss plutonically. And if syenite and granite were igneous rocks it were impossible for magnetic iron to separate from them. Wet segregation alone remains.

Bischof then instances the quartz crystals in magnetic ore in various mines, and such intimate admixtures of granular granite and quartz and hornblende crystals with iron as to become ore beds.

At Falun the pyrites of copper, iron, lead and zinc occur in quartz gangue. In the Breadgang mine the gangue is quartz, hornblende, garnet and calcspar. [The American beds show the same.] Should the ultra-plutonists grant that the accompanying quartz is of watery origin (compelled by such facts as the discoloration of green topaz by heat) but still claim an igneous origin for the magnetic iron, they will find no escape this way, for the welding trick must be repeated on a grander scale in a supposed molten ore vein enveloping quartz, forming a silicate slag. Moreover Weibye shows that at Arendal the segregations diminish in number as one descends, and hence the present scarcity of minerals once so common in these mines, for they exist in the segregations. If now the ore were plutonic, from the earth's centre, the reverse would be the fact. Leaving the day and nearing the centre we near the fire, but leave behind the water. Water and not fire therefore aggregated these mineral masses.

In the Island Langö the magnetic ores in mica-gneiss, in quarzite, in massive granite, etc. are apparently everywhere surrounded by trap-rocks and even penetrate these so that Weibye considers them of trappean origin. Yes says Bischof—segregated from trap.

But are all the Norwegian magnetic ores conversions from augite? a hard question dependent upon a larger synthesis of analyses, in which lime and magnesia, carbon and silica, talc, serpentine, kokkolith and analcime play their parts. There are of course difficulties in accounting for it where a whole mountain of **augite-porphyry is turned into magnetic iron.** Recollecting that only carbonated waters act upon this mineral, we see that when the augite (if rich in iron) decom-

poses, lime and magnesia will be entirely and protoxide of iron partially carried off, with silica (as the decomposition of Rhodonite and Bustamite shows, p. 557), some protoxide remaining and peroxidizing; when the labradorite decomposes (by the carbonated waters) lime and soda are carried off and kaoline remains; the combined result will be **magnetic iron and kaoline.** In the magnet mountain *Wissokaja Gora* we do not find the clay mixed with the iron, but underlying it and walling the rock which Hermann describes as an impure (*i. e.* a weathered) porphyry composed of red-green jasper with feldspar and scattered quartz grains. . . . . We are not to imagine the soluble constituents of augite and augite porphyry washed away for that would leave but 26 per cent of protoxide or 28 of magnetic iron (in augite), or only 8 per cent of the augite porphyry mass behind; but the materials suffer decomposition in the bed which in fact has its volume even enlarged by the lime taking up carbonic acid and the protoxide of iron taking up oxygen.[5] . . . . .

The difficulties which Bischof confesses and details are such as appeal rather to the chemist than to the geologist. On the other hand the geologist feels a difficulty which seems to have been scarcely perceived by the chemist, to wit, the rare occurrence of magnetic ore beds in rocks which according to this hypothesis might produce them anywhere and in any required magnitude, and especially their recurrence along well-established planes or at certain fixed geological times in the long sequence of deposits.

A basis of explanation however must be adopted essentially the same as that on which Bischof so firmly stands, even by those who feel this difficulty most. The following extract from a letter of one of our most distinguished American chemists[6] trained geologically in the field, is published here, without apology to the reader and with the author's kind permission, to support these views:

I see no reason for assigning any other than a sedimentary origin to the magnetic and specular iron ores of the crystalline schists, nor do I conceive that the conditions under which they were deposited differed essentially from those which at the present day give rise to beds of limonite and ochre. Kindler and Daubrée have shown that waters containing organic matters from vegetable decay reduce to the state of protoxide the peroxide of iron in sediments and remove it in a soluble form. The atmospheric oxygen again peroxidizing the iron, it is precipitated from these waters as hydrated peroxide, often combined with much organic matter (apocrenic, geic, or some allied acid). When owing to a complete oxidation of the organic matter the iron is held in solution as bi-carbonate, it may be deposited under conditions of diminished temperature and pressure in the form of carbonate, provided the air be excluded. In this way carbonate of iron is now being formed in the valley of Bröhl in the Eifel, according to Bischof.

[5] Bischof, vol ii. pp. 570 to 583.

[6] T. Sterry Hunt, Chemist to the Canada Geological Survey. Montreal, December 1858.

In all these cases which result in the production of carbonate of protoxide of iron, hydrous peroxide or organic salts of the latter, the accumulation of this metal is dependent upon its removal from preëxisting sediments. Accordingly we find that white clays and sands in recent deposits, not less than in the tertiary, cretaceous, carboniferous strata of various regions, are connected with the presence of beds of iron ores. In the same way we find in the oldest known rocks, those of the Laurentian system, on the one hand great deposits of iron ore, and on the other immense beds of soda-feldspar rocks almost entirely destitute of iron. Analogy leads us to suppose even here, as in the fire-clays and iron-stones of the coal period and the bleached sands and bog ores of the present time, the intervention of organic matters, a view which is strengthened by the presence of graphite in these strata, and even in the beds of magnetite themselves. Bitumen and an impure coal, according to Durocher, are associated with the iron ores of the Laurentian system in Scandinavia. The existence of graphite in magnetic iron ores is evidently fatal to the theory of their igneous origin.

The intervention of soluble sulphates, as is well known, modifies the result of the reducing action of organic matters upon oxide of iron and gives rise to pyrites, a type of that reaction which has produced the *fahlbands* (or interstratified beds impregnated with various metallic sulphurets), which are especially abundant in the older rocks

The association of iron ores with magnesian rocks in various regions deserves to be noticed. We find carbonate of iron passing into highly ferriferous dolomites and magnesites; silicious beds of the latter yield as results of their alteration, mixtures of talc and chlorite with crystalline oxides of iron, forming the rocks which have been named itabirite and catawbarite.

Although organic matters have undoubtedly been the great agents in the formation of iron ores, the intervention of mineral acids as a solvent of the oxide is not to be overlooked. The muriatic and sulphuric acids from volcanic and other sources give rise to solutions of iron, and the oxidation of pyrites and alum-schists affords sulphates both of iron and alumina. The decomposition of such solutions in limited basins by alkaline or earthy carbonates must give rise to deposits of oxide of iron, and where aluminous salts prevail alumina will be separated. Such I conceive to have been the origin of emery, which, as Lawrence Smith has shown, is essentially a mixture of crystalline alumina (corundum) with magnetite.

In 1837 Fuchs published his reasoning against the view that the crystalline rocks were once in a state of fusion, as follows: using granite as the illustration. If granite were once in a molten condition, then as it cooled, in the first place, quartz must have crystallized out, and would have sunk down through the still molten mass, while feldspar and mica must have crystallized at a much later stage of the cooling, as the necessary result of their different degrees of fusibility.[7] Further, the inclusion of arsenical pyrites, sulphide of antimony, tourmaline, garnet, fluorspar, etc., by quartz, is incompatible with the crystallization of the latter from a state of fusion. Accordingly the doctrine of

[7] Am. Jour. Science (2) xxiii—229.

upheavals cannot be sustained. In enunciating his own views, Fuchs begins with the proposition, that amorphism must precede crystallization, and assumes that originally, the solid part of the earth consisted of silica and silicates in the amorphous form, while the liquid portions were largely made up of solutions of lime and magnesia or their carbonates, in the then existing excess of carbonic acid. "This I conceive to have been the primal, or chaotic condition of our globe; this may indeed have been preceded by another condition, but to this state it must have come before the formation of rocks could begin." The formation of rocks, according to Fuchs, began with the silicates.[8]

As the maturity of vegetation is found to depend upon the actual amount of heat obtained from the sun during the season, and not upon the time during which it is obtained, so the various products of the mineral world seem to be due to a certain aggregate amount of heat, time being only one of the factors, intensity of action being the other. The furious heat of a blast furnace or a volcano may produce in a few weeks or days crystals and amorphous compositions which in the moist and equably low temperature of the earth's crust have required centuries to mature.

Prof. Hausmann of Göttingen, has recently published a memoir on the formation of minerals in and about furnaces by furnace action. He enumerates the following varieties observed by him: silver, lead, copper, iron, bismuth, lead-glance, blende, oxide of zinc, red-copper ore, iron-glance, magnetic iron ore, crysolite, pyroxene containing alumina, Humboldtite, orthoclase, lead-vitriol, and arseniate of nickel. Brown, yellow, green and black blende were observed formed in the furnaces of the Lauten valley, Hartz, in regular octahedrons and dodecahedrons; also in lamellar and radiated concretions. Lead-glance, he informs us, is often formed by sublimations in the chimneys of furnaces, and the crystals are cubical with the usual cleavage; and crystals of magnetic iron sometimes incrust cavities in the stone or brickwork of the furnaces.[9]

The Roxbury conglomerate of Massachusetts found by Dr. Hayes of Boston to be for the most part a silicate of lime containing chlorine is traversed by bold trap dykes containing an abundance of sulphuret of iron, and by fissures filled with quartz which Dr. Hayes calls *sublimed*. He thinks that the silicate of lime was formed by the transportation of silica in the heated vapor of water to combine with the lime and alumina muds of the original gravel deposit, and not by the decomposition of chloride of calcium by hydrous silica. Dr. C. T. Jackson on the other hand in studying the various cements of sandstone and conglomerate, found sometimes

[8] A still stronger argument is advanced by Sorby. The water contained in granite and other so called igneous rocks proves conclusively that they have never been in a molten condition, or at all events did not crystallize from such a condition.

[9] Ann. of Sci. Dis. 1854, p. 320.

carbonate of lime, sometimes oxide of iron in excess, and sometimes a setting of the smaller sand and fragments as silicate of lime no doubt by decomposition of chloride of calcium, which is certainly a sea deposit, and which when pebbles are moistened with it and laid together will cement them with silicate of lime and let chlorine escape. The pebbles at Purgatory near Newport Rhode Island get their cement coating of specular iron from original chloride of iron sublimed (he thinks) by the heat from the neighboring trap dykes.[1]

On the other hand, M. de Sanarmont has been able to realize minerals in the humid way which have been hitherto considered solely of igneous origin. The following communication, read before the French Academy by M. de Sanarmont, is worth giving entire:

Geology has means of investigation which are peculiar to itself, and now comprehend a certain number of special truths definitely acquired to science. It is thus that Geology has been able, without foreign aid, to characterize the manner of the formation of the sedimentary rocks, and to arrange them in series; it is thus that it has succeeded in distinguishing in crystalline rocks, and in metalliferous repositories different classes of which it can assign the probable origin; and in so far as it has not drawn conclusions too far removed from its fundamental principles, its anticipations have been almost always confirmed by experiment. It is to mineralogical chemistry that geology owes the useful experimental control of its rational conceptions. Crystalline minerals have, in fact, a complete chemical origin; and a more thorough study and knowledge of them must be advanced by chemical experiment.

Chemistry, then, can do much for geology by lending its means for experiment; but upon the condition of itself remaining purely geological, and of borrowing in its turn particular means of study, and the general data which the science *a priori* has collected upon all the conditional peculiarities of structure, relative position, association or mutual exclusion, to which certain mineral species must needs be subject. In a word, it is necessary that all the circumstances where the natural operation has left characteristic traces, discovered by the geologist, should reappear in the artificial operation of the chemist.

The experiments, then, of mineralogical synthesis should embrace the different groups of mineral species which are united in nature, and should support themselves upon certain probable geological inductions concerning the formation of the beds which they inclose. Certain isolated species have already been obtained, and principally those which approximate to the usual products according to the dry method. I have attempted to do more, and to discover some indices of the general causes which have originated the different classes of metalliferous beds. I commence this problem by the study of the concretionary veins which approach most nearly to the existing formations, and the principles I have just explained have been the starting point of the researches I am about to submit to the Academy.

The concretionary repositories seemed to be formed by solution; the mineral species we there find would then be the products of the humid method, derived from liquid deposits, and to a certain extent may be compared to geysers and thermal springs. Moreover, the principles most generally prevalent, even at the present day, in these springs, are the carbonic and hydrosulphuric acids, the alkaline salts,

[1] Annual of Sc. Dis. 1858, 26.*

and amongst others the carbonates and the sulphates; these then are the reagents I propose first to employ. But amongst the different influences which may modify in the subterranean canals, the usual chemical reactions, we must undoubtedly reckon first pressure, and a temperature increasing indefinitely with the depth; and I have endeavored to realize this double experimental condition. It is very evident that this creates numerous difficulties; and we must not be surprised if the crystalline state of the products thus formed is sometimes imperfect, and always microscopic. Besides, it is not the size of the crystals which results from such problems, it is the mere fact of their creation; and in order to obtain more, all that is required is time, space and rest—powerful means which belong to nature alone.

The method I have pursued essentially consists in producing all the chemical reactions **in a liquid condition,** and in glass tubes, hermetically sealed, heated from 100° to 350° C. I have almost solely employed solutions of carbonic and hydrosulphuric gases, of bicarbonates and alkaline sulphurs, alone or mixed in variable proportions; I have, then, I repeat, as a starting point, the composition of mineral waters and their most energetic principles. By these means of procedure I have artificially formed a great number of natural compounds. Each family of minerals generally group themselves around a common generating agent; so that we might then classify them thus in relation to the presumed composition of the thermal depositions which have served to produce them. I do not wish to make this approximation too absolutely; as it appears to me to go beyond the immediate interpretation of the facts; and I shall limit myself here to the mention of the compounds which I have obtained, and the different classes of minerals to which they belong.

Native Metals.—Copper and silver, mixed but not combined, as observed in certain mineral repositories in North America. Native arsenic.

Oxides.—**Red iron ore** Fe^2O^3. Quartz $Si O^3$, in regular six-sided prisms, acuminated with six planes, with striæ, and sometimes with unequally developed acuminating planes, so frequent in natural crystals. Red copper ore, or red oxide of copper, in red shining translucent octahedrons.

Carbonates.—Carbonates of magnesia, of iron, of manganese, of cobalt, of nickel, of zinc, of copper or malachite.

Sulphates.—Sulphate of baryta, in the primitive form.

Sulphurets.—Realgar, in transparent crystals, with the colors, lustre and form, as in mineral veins. Sulphuret of antimony, in acicular, shining, metallic-looking crystals. Sulphuret of bismuth with similar characters as the preceding. Sulphurets of iron, of manganese, of cobalt, of nickel, of zinc, of copper. These last mentioned are massive, as is the case with those prepared in our laboratories; but it appears that the hydrosulphuric acid, under certain conditions of temperature and pressure, is a solvent of sulphurets, and a general agent of crystallization. The properties of this acid explain the accumulation of metallic sulphurets in the deep parts of mineral repositories, and of metallic carbonates near their crop, or outgoings. Arsenio-sulphurets and antimonio-sulphurets were also formed.

Conclusions.—I had proposed to establish, upon experimental proofs, the controverted, and, as I think, very probable opinion, which attributes the filling up of the concretionary veins to incrusting thermal depositions, and to show that the formation of a great number of minerals which we there meet, whether they be crystallized or amorphous, do not always pre-suppose conditions or agents far removed from the actual existing causes. We thus, in fact, perceive, that the two principal elements of the most widely extended thermal springs, the sulphurets and the alka-

line bicarbonates, have sufficed to produce twenty-nine distinct mineral species, almost all crystallized, belonging to all the great families of the chemical compounds peculiar to concretionary beds, each of which has some representatives in my experiments. Means of synthesis equally simple, applicable however to compounds as variable, give certainly a great probability to the speculative ideas which have directed me in these researches. It will moreover be necessary to diversify them to a much greater extent, and when we shall in the same manner have studied the different chemical agents, and the influences of every kind which can modify their effects, we shall undoubtedly succeed in defining the probable condition of the formation peculiar to each class of metalliferous beds; and in tracing their origin step by step, in the same order of systematic experiments, we may finally arrive at the crystallized rocks which associate themselves to these beds by methods and phenomena of continuity which it is impossible to mistake.[2]

All this goes to sustain the judgment of the eclectics who accept the igneous origin of lava rocks of every age and yet are disposed to acknowledge the increasing evidence in favor of the chemical and chemico-sedimentary origin of perhaps a majority of the silicious, dolomitic and metallic, and even a few of the trachytic and trappean members of the earth-crust, and certainly of almost all the so-called primary iron ores. The red specular or primary red hematite beds of the St. Lawrence are confessedly sedimentary.

At a recent meeting of the Boston Society of Natural History, Dr. A. A. Hayes exhibited some specimens, resembling Trachyte rock so closely, that most observers would have mistaken them for Trachyte.

The specimens consisted of hand specimens, having the uneven fracture of trachyte, full of capillary passages, with some cavities; there were fractured planes of brown and flesh-colored minerals, resembling feldspar, and some small red, brown-colored and black granules; but the most characteristic mark was the occurrence of angular fragments and grains of yellowish green color, hardly distinguishable from *epidote* by the eye. The external surface was brown and uneven, like that of a weathered basalt, or trap. The island from which these specimens came has been examined by a geologist, and from the prevalence of this rock, it is said that he pronounced the island to be of volcanic origin. A mass was sent to Dr. Hayes, and he found it had structural planes, the divisions producing trapezoidal masses, their surfaces and the lines marked by darker colors, and, so far as could be determined, there was evidence of the mass being part of a rock formation of some extent.

The chemical composition discloses the remarkable fact that this rock is composed essentially of fish bones and altered shells, which have passed through the alimentary canals of sea fowls. Referring to communications before made,[3] Dr. Hayes stated that the organic matter of fish bones in the droppings of fowl, reacts on the bone phosphate of lime, to eliminate acid salts of phosphoric acid, and these cement other portions, or decompose shells, which are composed of carbonate of lime and animal tissues. The feldspar-like granules are generally compact, colored portions of converted shells, having a crystalline form, and there are aggregates of ferrugin-

[2] Annual of Scientific Discovery for 1854, pp. 320–322.

[3] See Annual of Scientific Discovery for 1857, pp. 242, 243, 244.

ous and aluminous phosphates, arising from the same kind of action on ferruginous matter, which, in the form of a fine clay, or volcanic ash, has been brought within the sphere of the action of the acid phosphates. The cavities sometimes present minute crystalline facets of phosphate of lime crystals, while the capillary channels and pores, which give the trachyte-like character, are really the passages through which the carbonic acid and other gases escaped, during the transformation of the organic matter, precisely as they occur in basalt and trap, where igneous action has been supposed to have been influential.

This rock is covered more or less by Atlantic guano rock, presenting the variety which consists of compact, light-colored phosphate of lime, containing about twenty parts in one hundred of carbonate of lime, and in some parts is a consolidated shell-bank; the recent shells and coral fragments being visible. Where, through time and favorable exposure, the bone remains have thoroughly decomposed the shells, hand specimens would be mistaken for the flesh-colored, massive phosphate of lime of New Jersey. These more or less well cemented and altered rocks are also connected with still more recent deposits, retaining even the odorous animal remains of oily acids; and the whole formation, above that of the trachytic form of rock, contains the remains of infusoria. Thus a small island of the Atlantic, lying about eighteen degrees north of the equator, presents us with an epitomized succession of rock strata, formed from materials which, once endowed with life, have served to nourish other living systems, and then given rise to chemical changes, resulting in the production of various mineral solids which remain. The trachyte-like rock forming the basis rock of this island, theoretically, may have received its geological and chemical characters in ocean water. A subsidence of the land, after its surface had been deeply covered with organic remains, would allow of that aqueous action of decomposition and cementation which we notice, and the subsequent desiccation would explain the natural divisions by rents. The formation of silicates of iron, manganese, and alumina from phosphates of lime, is a mineralizing process which can take place in ocean water by infiltration, volcanic ashes, or divided materials of plastic rocks being present, as analysis shows them to be. The rock is hydrous, losing nearly 10 per cent of its weight by ignition, or water with a little organic matter, 10.00; bone phosphate of lime, 85.20; carbonate of lime, 3.00; oxides iron, manganese and alumina, 5.22; silicic acid and sand, 1.78; total, 105.20. The excess of weight being due to the estimation of the phosphoric acid united to lime as bone phosphate of lime, while truly part of it, with a portion of silica, is united to the oxides present.

These facts prove that mineral masses containing phosphate of lime, may be thus formed from animal phosphate of lime, and present all the characters which we recognize in the phosphate of lime contained in the oldest slates. Additional interest has been given to this subject by the investigations of Professor Booth of Philadelphia, and Dr. Piggott of Baltimore, who have analyzed specimens in which the phosphoric acid had combined with both oxide of iron and alumina.[4]

Mr. Taylor of Philadelphia exhibited to the Academy of Natural History there a fragment or ball apparently of trap involved in chalcedonic guano.

Beds of carbonate of iron have been considered the natural chemical iron precipitations of the ocean charged with river solutions of the sulphate. But iron deposited from sea water,

[4] Ann. of Sci. Disc. Boston, 1858.

when the water was charged with organic matter, in ancient as in modern days must have fallen in the form of a peroxide, and must have been mixed with a sediment from river and ocean currents of a very varied mineral character principally silicate of alumina and carbonate of lime and magnesia. Sorby's paper on the Cleveland Hill Iron-stones[5] shows by microscope and analysis how shells of carbonate of lime are replaced gradually by casts of carbonate of iron. Original deposits of mingled carbonate of lime + peroxide of iron would result in beds of carbonate protoxide of iron;

(Peroxide iron +
Carbonate lime . . makes . . Carbon. Protox. iron
+ Oxygen set free)

which would find many substances to oxidize and would busy itself first of all with any free hydrogen it could find, and then with any carbon of animal or vegetable matter. It is very likely that the excessive polarity of oxygen and hydrogen would read for us the riddle of most of these changes. If now the action of carb. protox. iron upon phos. of lime be (as it is) to produce phos. iron

(Carb. protox. iron +
Phosphate lime . . makes . . Phosphate iron
+ Carbonate lime set free)

and if there are indications that its effect upon sil. alumina (clay) is analogous

(Carb. protox. iron +
Silicate alumina . . makes . . Silicate iron
+ Alumina pure + Carbonic acid set free)

then we have all the elements of the carbonate ore beds with their tinted white clays, and traceable impurities.

Bischof found that carbonic acid was gradually separated from carbonate of lime by silicic acid with the cooperation of boiling water. This decomposition took place, whether the silicic acid was in a soluble or insoluble condition; for even finely pulverized quartz decomposed the carbonate of lime, the process in that case being rather slower. Carbonate of iron and the carbonate of magnesia behave in like manner; the latter is decomposed even more easily and in greater quantity than the carbonate of lime. The more facile decomposition of carbonate of magnesia is shown by the fact that even boiling water by itself separates the carbonic acid from it, **this not being the case with the carbonate of iron.** When therefore either limestone. dolomite, or sparry iron, occurs at a depth beneath the earth's surface where boiling-water-heat exists and water has access, carbonic acid will be driven off from these carbonated salts. The Soffoni in Tuscany, discharging boiling hot water from crevices in limestone, must come from a depth where boiling heat exists, and it is very probable that the accompanying carbonic acid arises from

[5] In the Proc. of the Geol. and Poly. Soc. of the West Riding, July 30, 1856, p. 458.

the above mentioned causes. The same must be admitted for the carbonic acid discharged so abundantly in the neighborhood of ancient localities of volcanic action in various parts of central Europe. According to the laws of the increase of temperature towards the centre of the earth, we may calculate that boiling heat exists at a depth of about 8,600 feet in these districts, and this depth is certainly within the limits of the clay slate formation of Germany, which is calculated to be at least a mile (German) thick. Calcareous beds (transition limestone) and quartzose rocks occur at this depth; waters penetrate thereto, and carbonic acid is separated from the limestone, as in the above mentioned experiments. To account therefore for the origin of carbonic acid exhalations, we need no more assume that the focus must be where red heat exists, which presupposes a depth of at least five miles (German); for the clay slate or any other sedimentary formation may be the seat of the evolution of the gas, since only in the moderate depths of about half a mile (German) the materials required are present.[6]

Taking the deposits of carbonate of iron as a new starting point at a subsequent era, namely, when the deposits were uplifted, truncated, dried and exposed to the chemical action of the atmosphere, we merely get the phenomena of the coal measures with their hematized outcrops and solid unchanged carbonate beds. If then we see by the supposition once solid carbonate beds changed into solid amorphous or crystalline peroxide or proto-peroxide beds, the change must have been effected at a time previous to the uplift and exposure—except of course in the presence of volcanic dykes which all agree effects the transformation in open air. It is necessary therefore to consider the change as effected during the earliest times, earlier than the early outlifts. Speculatively there are but two agencies at our command for this purpose, interior heat and electro-magnetic action with moisture under pressure. The suggestion, that the original peroxide iron deposit may however have been elevated too soon after its deposition to have suffered the change to carbonate, is met by the fact that in going back to peroxidation the carbonate in open air always becomes a *hydrated brown* peroxide. This *gossan* at the outcrop of an ancient vein is always broadly distinguishable from the specular *anhydrous* peroxide body of it. How must we account for the *an*hydrous state then of ancient veins, say of the Huronian and Lawrentian rocks? Are they original *local*, perhaps *subcerial*, perhaps marshy deposits of hydrous brown hematites deprived of their water by subsequent heat? Those who consider the metamorphosis of the inclosing rocks due to a sub-igneous pro-

[6] Ann. Sci. Disc. 1852, p. 288.

cess will readily allow us to use this explanation. Were they original *deep sea* deposits of hydrous peroxide dried by the same similar semi-volcanic heat during the times when the deep sea was filling up its bed? or hydrous peroxides deposited around springs in the bed of a slowly sinking sea?

The red anhydrous peroxide beds of the Huronian or Upper Azoic rocks may be ancient hydrated brown hematite beds deprived in some way of their water, say by a steady universal temperature of the inclosing rocks sufficiently high; a cause which will be readily allowed by those who consider the metamorphism of the inclosing rocks to be a sub-igneous process. We have anhydrous red oxide oölitic and fossiliferous beds in the Upper Silurian formation (No. V. Clinton group) of the United States and in the Jurassic, Cretaceous and Super-cretaceous Middle Tertiary beds of Champagne and Berry in Europe, which could not have been originally formed as hydrates and then dehydrated by heat, for the rocks on and in which they lie are in an unchanged state. If originally hydrates, some *chemical* action has removed the water from these ores, and the same action could go on at earlier ages, among the Huronian deposits.

The same train of thought takes up the anhydrous peroxide crystallized specular iron ores, and finally the partially deoxidized proto-peroxide magnetic ores, which have been considered par excellence igneous products. It is granted that these are confined to the oldest of all known rocks, and therefore have been subjected for the longest time to the slowest and therefore the most powerfully alterative living chemistry of the planet. If we suppose them to have been deposited at first as beds of impure carbonate of iron, there is no difficulty in picturing them changing to brown hydrous hematites, then suffering dehydration, and finally partial deoxidation by the most probable and yet the most powerful of our laboratory reagents, hydrogen. If it be asked where is the hydrogen to come from, the answer is given by whatever modification of Davy's theory may be adopted; the oxidation of the earthy bases by water sets free hydrogen (it has been detected in volcanic eruptions), which in its way through the earth crust must seize upon all peroxidated materials and protoxidize them, as it does in a hot glass tube. Dr. Euhler finds that even sulphate of lime (and to the extent of tons at once) is reduced by organic matter in a state of *active*

fermentation (sulphide of calcium being thrown down and sulphuretted hydrogen being set free[7]), not by the affinity of oxygen for carbon or carbon for lime or sulphur for hydrogen but by the intense affinity of hydrogen for nitrogen. But this fact comes in to our third chapter. Here it is only intended to suggest possible or probable methods of obtaining iron in any of its mineral combinations in the oldest rocks without having resort to the igneous theory, and without doing violence to the known conditions under which the majority of primitive veins are seen. The mere fact that grains of hydrous red oxide are disseminated through jurassic and other unchanged strata, just as crystals of magnetic and specular iron are through the metamorphic older slates and sandstones—taken in connection with the fact that *all* mica-rocks *must* contain at least 14 per cent of their proportion of mica in the form of iron—shows how chemical changes from one form of iron ore to another explain the once considered igneous outbursts of our older ores. The granites so called (but they are properly metamorphic sandstones) of the Highlands of the Hudson contain zircons and octahedral crystals of iron; of course both are chemical, not volcanic, productions. The so-called granite of Clinton county in northern New York, properly metamorphic Lawrentian sand stone is traversed by lodes of magnetic iron, as at the state prison, and at Arnold hill; but one of the "veins" in Arnold hill is a *peroxide*;[8] it would consequently seem that they must all have been chemical and not volcanic productions. The "granite" of the Thousand islands of the St. Lawrence contains, (with peroxide of iron, sulphuret of iron and copper barytes, strontia and fluor spar,[9]) the *carbonate of strontia* and therefore can hardly be an igneous production; and Emmons adds that "its ores and minerals occur in nests and strings which run out and hence has ever proved an unsafe rock in mining," which looks still less like volcanic eruption. The kind of "granite" called *hypersthene* containing lime and soda, but very little

[7] See Bischof, Lehrbuch der Chemischen und Physikalischen Chemie, i. 653, i. 655, i. 661, i. 533, etc.—F. A. Genth.

[8] Emmons's American Geol. vol. i. p. 67.

[9] The law of the diffusion of fluorine may be thus expressed: There is fluorid of calcium in all waters containing bicarbonate of lime and therefore there may be fluorine in all rocks and minerals formed in a sedimentary way.—J. Nickles, *in Silliman's Journal, Jan.* 7, 1858, p. 119.

quartz and no mica, being in fact merely a Huronian sandy magnesian limestone with from 5 to 25 per cent of iron in it without the shadow of a claim to plutonic origin, has nevertheless grains of magnetic iron disseminated through its strata, which form the Adirondac mountains west of Lake Champlain. And it is in these hypersthene Huronian strata just underneath the Potsdam sandstone or the base of the Lower Silurian palæozoic rocks, that the great magnetic iron ore beds of northern New York, sometimes charged with phosphate of lime, appear, and always in the form of chemico-sedimentary beds, never in the form of igneous veins. Here it is that Emmons finds his numerous evidences of the *igneous origin of primary limestones!*[1]—limestone beds which he traces through the States of New York and New Jersey, Pennsylvania and Virginia into the Carolinas, and yet are universally acknowledged to be merely metamorphosed Lower Silurian limestones everywhere along this continental belt; limestones which contain disseminated octahedral and magnetic iron crystals, graphite, phosphate of lime, spinelle, etc. etc. and always appear in the immediate vicinity of the magnetic ore beds of the Highland—South Mountain—Blue Ridge range. The serpentine marbles of Milford and New Haven in Connecticut and the serpentines of Vermont and eastern Canada known to be metamorphosed (Hudson river) Upper Silurian magnesian sediments, as well as the older Azoic (Huronian) serpentines of Northampton and Lancaster counties Pennsylvania and St. Lawrence county New York contain or are immediately associated with either chromic or titaniferous iron or both. The serpentine is not always massively bedded but often laminated like gneiss or altered sandy shales. It usually passes into or lies in contact with steatite (true soap-stone) and its igneous origin is now pretty nearly given up.[2] Even Emmons says that " the evidence of its igneous origin is less than that of primary limestone," and that he has never seen it in narrow veins and dykes like greenstone. The Vermont serpentines are perfectly sedimentary, and the Canada serpentines are seen passing into Hudson river strata (at the top of Formation III.) That of Troy Vermont near the Canada line is traversed by a wedge form vein of magnetic iron.[3] The

[1] See his treatise on pyrocrystalline limestone in American Geology, vol. i. p. 77.

[2] It is a hydrous bisilicate of magnesia. Emmons's Am. Geol. p. 85.

large quantities of silicious sinter in the serpentine ot Macon Georgia[4] suggests a hot-spring origin for the serpentine, and recalls the buhrstone deposit with its iron ore of the coal measures. The serpentines of St. Lawrence county New York are often associated with earthy oxides of iron containing angular pieces of quartz from $\frac{1}{10}$ to $\frac{1}{2}$ inch diameter closely invested with serpentine; the ore and serpentine are here "somewhat blended with" the Potsdam sandstone.[5] The serpentine belt of Port Henry decomposes into a scoria as if it had been originally porous and the pores filled with carbonate of lime,[6] or more likely an original mixed precipitate in which the carbonate of lime segregated into innumerable small nodules. There are sedimentary serpentines of Devonian (Waterlime) age near Syracuse in western New York, nowhere near erupted rocks and therefore sedimentary, perhaps through hot springs.

At the Parrish mine St. Lawrence county according to Emmons' drawing (Fig. 13 page 88, American Geology) the mass of "rather silicious" ore capped by horizontal Potsdam sandstone (No. 1), rests on or against a "protruded" mass of serpentine on the other side of which gneiss rocks slope down, covered with Potsdam sandstone. He remarks that a similar dislocation is known in a contiguous vein known as the Kearney ore bed. But in Fig. 15 (page 89) he draws the Theresa specular ore beds as a regular deposit dipping both ways across a broken anticlinal, in the axis of which is seen a grand radiation downwards of serpentine resembling very much an emerging Vesuvius. "Instances of the same kind and character" he continues "might be multiplied," and "the facts revealed by the relations of the associated rocks support the view that serpentine is truly an eruptive rock and belongs to the same class as granite and sienite." But he also says on the same page (88) that limestone intermixed with serpentine appears in the gneiss on the east side of the harbor at Whitehall and has disturbed the superincumbent Potsdam sandstone. The truth is that all these drawings are too much distorted to convey the proper meaning of the local geology which they are intended to represent and therefore confound instead of enlightening the judgment. They bear no geological resemblance to the origi-

[4] Emmons's Am Geol p. 85. [5] Emmons's Am. Geol. p. 87.
[6] Emmons's Am. Geol. p. 85.

nals. They serve only to establish a fact directly at variance with the conclusion of their author, to wit, that in all these instances serpentine and iron ore appear at the top of the gneiss just beneath the Potsdam sandstone, and near limestone; which when more carefully considered means *in* the extreme bottom rocks of the Lower Silurian or Palæozoic series; just where they *reappear* in New Jersey and Pennsylvania. In fact he gives in fig. 27 on page 95 of his New York Report the "serpentine highly charged with quartz," quietly and conformably dipping 50° between regular layers of "sandstone intimately mixed with peroxide of iron, with which also there are rich masses of ore." Further illustration is needless. The serpentines cannot be eruptive; and, conversely, must be sedimentary. And Professor Emmons instinctively feeling the force of this conclusion announces it himself on page 89 by describing "the serpentine belt" as "coextensive with the Green Mountains, Highlands and Blue Ridge as far south as Georgia, and chromiferous through its entire extent." Yet he goes on to quote Dr. Jackson's single locality of serpentine in Maine on Deer island, connected with that mass of the Grand Menan in Nova Scotia as "erupted through granite." The serpentines of Johnstown Canada West like those of northern New York, he says, differ from the great Atlantic belt by showing graphite, amphibole and pyroxene commonly, whereas these minerals are rare (as belonging to the serpentine itself) in the belt referred to. This is a just distinction. The two are of similar origin, but of different ages. The serpentines at least of the Green Mountains are as late as the close of the Lower Silurian age. The others just precede or accompany its opening. This explains the fact which Dr. Emmons thinks "rather remarkable, that serpentine though it forms by itself hills of a moderate elevation, yet does not appear in the higher parts of the Appalachians." If eruptive and in such masses as he describes it in Franklin, Macon and Cherokee counties North Carolina, and of any age (as a true eruptive rock must be), it would have formed mountains, or appeared at times at the summit of the Blue Ridge and Highlands. But being a sedimentary rock associated with the soft magnesian limestones and slates of the Hudson river group—and with the limestones and slates of the Potsdam and uppermost azoic rocks, its place is in the valley, at the edges of the

great valley, at the base of the North mountain, and at the base on each side of the South mountain and there it must stay; for the mountain "granite" itself is not eruptive but sedimentary, of a fixed age, appearing in a fixed place and occupying a well established line not of outburst, but of simple upheave and denuded outcrop, through the Atlantic States.

Chromic iron is one of the most constant companions of serpentine, and magnetic iron and copper occur in it also. Rammelsberg has published an elaborate investigation of the titaniferous iron ores the principal results of which are given in Silliman's Journal as follows: (1.) The greater number of the titaniferous iron ores, among them all the crystallized forms, consist of 1 equivalent of titanic acid and 1 of protoxide of iron (protox. of manganese or magnesia). (2.) Magnesia is an essential constituent of all these ores and in the crystallized mineral from Layton to the extent of 14 per cent. (3.) Mosander's theory, that the titaniferous iron ores are either simple titanates of protoxide iron (with isomorphed admixtures of titan. mag.), or mixtures of such with sesquioxide iron for the most part in simple proportions—is preferable to Rose's that these ores are isomorph sesquioxide of titanium and iron (involving therefore the assumption of a sesquioxide of magnesium). (7.) No titaniferous iron crystallizing in regular octahedrons is known; the dense masses or octahedral grains are mixtures. (8.) *Crystallized magnetic iron ores contain no titanium;* they consist of one atom protoxide and one atom sesquioxide. (9.) All the Elba iron ore does not contain titanium, but all (like that of Vesuvius) contains magnesia and protoxide iron. (10.) The strongly magnetic octahedrons from Vesuvius, hitherto considered as a specular iron, which are accompanied by rhombohedrons of specular iron, contain in part large quantities of magnesia and in part protoxide of iron, and consist either of magnetic iron partially converted into sesquioxide iron and of isomorphous magnesia + perox. iron—or more probably of two protoxides (isomorphous) with sesquioxide of iron (itself dimorphous).[7]

In spite of all that has been said the presence of trap dykes is sure to develop in a peroxide bed magnetic ore and to lend a strong color thus to the igneous theory.

Magnetic octahedral and also massive ore is found according to Dawson[8] in trap on Partridge Island and in the North mountains of King's county Nova Scotia; and tabular crystals of specular ore at Sandy Cove. But these minerals are in so small a quantity as to be of no mining importance. Geologically they are interesting because the trap accompanies the newer secondary (New Red) sandstone in Nova Scotia, as in New England and the Middle States, where it develops magnetic iron in deposits lying at the borders of the red sandstone but belonging to the Lower Silurian slates on which it rests; as will be said hereafter.

Taking up the beds of Primary ores in an order **from northeast to southwest,** beginning with Nova Scotia, New Brunswick and Canada, tracing the great azoic belt through the seaboard States, and concluding with the inland islands of Missouri and Arkansas, the first we find described is of peculiar

[7] Poggendorf's Annals civ. 497.

[8] Acadian Geology, 1855, p. 99.

interest, reopening the whole ground of the foregoing discussion.

Along the **Nova Scotian** isthmus runs the metamorphic (gneissoid) range of the Cobequid hills, over a thousand feet high, and supposed by Dawson to be Devonian and Upper Silurian; "there is no reason," he says, "to believe any of them older," although Marcou on purely theoretical grounds makes them of azoic age by identifying them with one of Elie de Beaumont's European crystalline axes. Along the southern side of this range the carboniferous rocks abut against the devonian, not in a regular line of superposed outcrops, but along a great northeast dislocation with a downthrow to the southeast, in some kind of connection with which runs the great ore bed of the region, best seen near the Great Village and Folly rivers. The vein has been long known; was described by Duncan about 1835, explored by Dawson in October 1845, reported on by Archibald and Dawson of London in 1846, examined again by J. L. Hayes of Portsmouth and Dawson in 1849, and opened at the erection of the Acadia furnace on the Great Village river. Here the carboniferous and metamorphic strata come together on a strike line N. 55° E., grey and brown sandstones and shales S. 65°+ meeting black and olive slates nearly vertical, giving place at the falls a little north of the spot to grey quartzite and olive slates, beyond and still among which stands the vein. This looks as if it were of devonian age. Dawson goes on to say that in the bed of the river it is a network of fissures penetrated with quartzite and slate and filled with a crystalline compound of the carbonates of lime, iron and magnesia (a kind of *ankerite*) with a smaller quantity of red ochery and micaceous specular ore. This again looks like original ferruginous magnesian limestone beds slightly hematized and then metamorphosed. The hill is 327 feet high. Up this the bed grows wider and more ferriferous. At one place a trench across it shows 120 feet of ore. Its underlay to the south is regular and in the plane of stratification, but its other wall is irregular, and it contains horses of quartzite and olivanous slate with slickensides, especially large and numerous in the centre of the bed. It contains nearly pure peroxide, in black scales and masses; magnetic ore "introduced" with the last "into the vein by sublimation" (Dawson); ochery red ore, rich, fusible and most abundant, of variable

Nova Scotia.

quality, some of it nearly pure; and the triple carbonate (ankerite) some of it tinged red and containing scattered specular crystals, perox. iron 33, carb. iron 19.5, carb. lime 46, carb. mag. and sand 1. The white variety has no peroxide but only carb. iron 23, carb. lime 54, carb. mag. 22. There are also little veins of yellowish sparry carbonate containing carb. mag. 20. running through the ankerite. "I have no doubt says Dawson that all these substances have been molten by heat and injected from beneath into the irregular fissure in which they are now found. The ochery red ore appears to be a result of the subsequent action of heat on the spathose iron." Certainly in the face of all the iron-ore phenomena of the coal measures, this is an unwarrantable hypothesis. On the outcrop of the vein yellow ochery iron ore containing balls of hydrous brown hematite abounds. Sulphate of baryta lines the fissures and fills small veins through the ankerite veinstone a white and coarse crystalline mass turning yellow and decomposing to a brown hematite. In some parts it is full of crystals and veinlets of yellowish spathic iron, and it is traversed by veins of red ochre even 6 feet thick and shapeless masses still thicker; also by irregular small specular veins and nests and disseminated crystals. At one part is a large mass of mixed magnetic and specular ore. Surely this bears no resemblance to an outflow of cast iron or homogeneous lava. Numerous transverse joints have apparently slightly heaved the vein, showing slickensides or coated with slate and ore. One of them is filled with flesh-colored sulphate of baryta an inch thick. The vein runs eastward magnetic N.98°E (variation 21°W) a course deviating about 33° from the containing rocks at Acadia, but much less elsewhere "and in general there is an approach to parallelism between the course of the vein and that of the rock formation of the hills, as well as that of the junction of the carboniferous and metamorphic systems." For several miles the distance between the vein and the lowest coal bed to the south of it is from 300 to 500 yards and the vein is "always is the same band of slate and quartzite." In its *westward* course large masses of specular ore are found in Cook's brook a mile from Acadia and a shaft 40 feet deep goes through its gossan; it has not been traced by Dawson beyond Martin brook, but he has received specimens of ore and

ankerite from the Five-islands twenty miles further on. *Eastward* a little copper pyrites was found on the vein which can be traced to the East fork, where the south dipping conglomerates rest uniformly on olive, black and brown (Devonian No. VIII?) slates striking N75East. Still further east Folly river shows the coarse grey S20°W dipping conglomerate rests on slate striking S70°W succeeded by 700 yards of quartzite up to the falls (55 feet high). These beds contain a few veins of ankerite and strings of ore but of no consequence. Above the falls they continue dipping 55° S for a quarter of a mile to a dyke of fine-grained hornblendic igneous rock. East of Folly river however the vein is largely developed where the Londonderry Mining Company's tunnel passes in northward through 190 feet of grey quartz and olive slate (and three feet of black slate) with a few strings of ankerite growing 17 feet thick at the broken irregular south wall of the vein, when it strikes red ore with specular nests and decomposed veins and blocks of ankerite and fragments of rock and goes through all this 10 feet without striking the north wall. Another digging further east finds neither north nor south wall. The vein is 13 feet thick with the micaceous specular ore more abundant and large rounded blocks of ankerite and angular fragments of rock. *The same appearance of transverse vertical layers seen at the Acadia mine is observed here.* Further east a cross trench 53 feet long is still in red and specular ore and ankerite. The vein was last seen by Dawson beyond Mill brook and he believes it to proceed far to the east. While he believes in its igneous origin he says " it is evidently wedge shaped, being largest and richest on the surface of the highest ridges," an apparent contradiction. The varied character of the bed is objectionable both in mining and in smelting, but the ore is too pure and abundant not to be worked in time to great advantage.

The above detailed description of this remarkable deposit has been given here because it shows the difficulties of the subject, and because it holds a middle station between the sedimentary coal-measure carbonate beds and the specular and magnetic beds of the primary rocks. Mr. Dawson describes " other and conformable beds of iron ore in the Devonian slates of Morse river Nictau, and East river Pictou, consisting of scales of

Nova Scotia.

specular ore firmly cemented together and intermixed with silicious and calcareous matter. At Morse river the ore has been in part converted into magnetic ore. At Nictau a bed of excellent ore 6 feet thick yields 55 per cent. At East river is a silicious bed of great size, yielding 40 per cent iron, not now worked, yet only ten miles from the Albion coal mines." [9]

In **New Brunswick** many small veins of magnetic ore sometimes ramifying through magnesian rocks have been noticed by Gesner in his annual reports. About 1½ miles west of Bull Moose Hill an abundance of coarse bog ore led to the discovery of a wide vein of magnetic ore running apparently several miles and within three miles of the bay into which Bellisle river runs. It runs through hornblende and feldspar rocks, and lies in the exact prolongation of argillaceous oxide beds in slate on the west side of the Long Reach on the opposite side of the Saint John, 25 miles distant.[1]

In **Canada East** Sir William Logan reports a magnetic ore bed six to eight yards wide in gneiss and 150 yards long, cut off with the gneiss by syenite, a little mixed with gneissic matter, but yielding 52 per cent of iron. Two other exhibitions of ore of little known value as yet are possibly in the same range and if so their common relation to certain Lawrentian limestone outcrops personally traced in zigzags for 80 miles by this distinguished and indefatigable geologist is of the highest interest, and would go far to settle the non-igneous origin of the oldest ores. The distance from the limestone is about a mile.[2]

In the early report of Mr. Murray in 1846 [3] we learn that the **region of the Ottowa river** is provided with magnetic and specular iron ores in many beds in Bedford, Bastard, Sherbrooke. In Hull township a magnetic ore 20 feet thick strikes north-northwest for perhaps a mile along a hollow bordered by nearly vertical syenitic gneiss stratified on the western side with white micaceous and graphitous granular limestones, white granular limestones occurring also on the east. The **Sherbrooke bed** on the north side of Myer's lake is an important mass of ore. In **Ross township** the ore vein cuts white granular limestone, steep, and underlaid by syenitic gneiss with

[9] Dawson's Acadian Geology, p. 328 to 342.
[1] Report (Third Annual), p. 54.
[2] Report of Progress, 1857, p. 40.
[3] p. 76.

hornblende and feldspar, in fact nearly a greenstone; it seemed to interlace and ramify through the limestone filling cracks from $\frac{1}{16}$ to 3 inches thick, sometimes turning off and running several yards in the strike of the limestone. It exhibits a passage from octahedral to cubic ore. Micaceous specular ore occurs 5 inches wide on the **Lac des chats** at Hudson's wharf, where white granular limestone (with mica and pyrites) underlies red syenitic gneiss. [This strongly reminds one of the deposits of brown oxide at the bottom of sandstones or sandy shales on top of limestone in the palæozoic rocks unchanged.] Its gangue here is quartz in the proper rock-strike. A fine vein 12 feet thick is seen on the opposite side of the lake dipping S 22° W < 70° over 100 feet of crystalline limestone and under compact grey limestone. It probably runs more than a mile and is lost in a swamp; weathers earthy red; breaks purplish red, in minute scales.

In **Maine** the most extensive deposit known at present is on the Aroostook river fifty miles above its mouth, a bed of red hematite fully 36 feet thick containing considerable manganese and shut up in metamorphic calcareous slates. A similar bed occurs near Woodstock in New Brunswick on the St. John's, where a charcoal furnace was erected in 1848. The ore could be delivered for 40 cents per ton. Thin magnetic ore veins are numerous along the coast.[4]

In New Hampshire, Amherst, multitudes of crystals of magnetic iron ore from one to two inches diameter, showing a passage from the octahedral to the rhombic, fall out of the decomposing granite rocks.[5]

In **New Hampshire, Winchester,** two miles south-south west of the church near the summit of Iron Hill, excavations abandoned before 1800 revealed beds of magnetic ore from 5 or 6 to 30 or 40 feet thick inclosed in gneiss and running N10° E one of them with a 30° to 50° dip west had been worked out 8 feet deep 200 feet along. The largest bed dips 40° east. The plan given on page 125 of the Report would show an anticlinal structure of the gneiss and a synclinal structure of the ore, but the section on page 126 shows no synclinal. The ore is heavy, massive, steel grey, thick bedded, with a little of it containing

[4] Whitney, p. 453.

[5] C. T. Jackson's Rep. p. 116.

pyrites, but easily picked pure. Rhode Island people, Hawkins, Jenks, Arnold and Cahoon, first smelted it in 1795 in a furnace where Furnace village now stands in the west part of the town.[6]

New Hampshire.

Heavy compact magnetic ore in small beds (less than a foot wide) occur in the non-micaceous granite of **Thorn Mountain** in Jackson New Hampshire, but can be useful for nothing but to mix with the Bald Face Mountain ore. The same occur in Piermont, near specular ore with sulphate of baryta, etc.

The great deposit of New Hampshire is in **Bald Face Mountain** one of the white hills between the rocky branch of the Saco and Ellis rivers in Bartlett, near the south line of Jackson. The mountain is "granite" with a few veins of greenstone trap. The iron ore occurs 1,404 feet above the Saco and a mile distant. One of the veins at the upper openings in 1844 was 37 feet wide east and west and 16 north and south, and the same in the opening 200 feet lower down the slope; 300 feet lower it is 10 feet and 400 feet lower 55 feet wide. It narrows again at 546 feet. A second large vein runs 250 feet west of the first. A third is indicated 50 feet further west. The general strike seems to be N37°E strike of the range. The ore is chiefly peroxide with some protoxide and a little oxide of manganese.[7]

The **Franconia** vein runs between granite walls N30°E, dipping 70° to 80° southeast. It was opened 40 rods long and 144 feet deep. When first opened it was 6 feet wide and diminished to 1½ feet.[8] Hot blast was introduced into Franconia furnace in 1844. In Benton magnetic ore from 6 inches to 3 feet wide quite irregular runs north in granular quartz.[9]

In **Vermont**[1] magnetic ore-crystals laminæ and fragments are widely disseminated and abound throughout the talcose and chlorite slates of the Green Mountains. These slates are metamorphosed Silurian or Devonian (No. III or VIII*) and elsewhere are full of crystals of sulphuret of iron. In **Plymouth** near the north line of the town, where the limestone (No. II) joins the talc slate, a vein of mixed magnetic and specular ore occurs dipping 70° east and the adjacent limestone beds are full of crystals of magnetic ore. In other counties fragments have

[6] C. T. Jackson's Rep. 1844, p. 126.
[7] C. T. Jackson's Report, p. 79.
[8] C. T. Jackson's Rep. p. 74.
[9] p. 109.
[1] See Adams' 1st, 2d, 3d and 4th Annual Reports, 1845–1848.
* Hitchcock.

been found. A curious vein of hornblende and magnetic ore 8 feet wide exists in **Brandon** on the top of the Green Mountain. Specular ore is seen in Chittenden, Brandon, Middlebury and Lincoln, and another range commences in Milton and seems to run through Franklin county into Canada. In **Milton** near the lake shore red-oxide of iron was once mined dipping 10° southeast, a mixture of ore and sandy limestone, the middle of the vein being heavy ore. A few rods northwest of **West Berkshire** village the same ore is seen in talc slate (met. No. III?). In **Crittenden** the granular quartz rock of the west slope of the mountains contains fine granular and crystalline specular ore, but not in regular veins. The crystals are pseudomorphs, non-magnetic red streak *octahedrons* and the rock has lost its stratification. Most of the smaller crystals are magnetic; some show a gradation into specular.[2]—**Chrome** iron has been found in the serpentines of Newfane.—**Titaniferous** magnetic ore, in the east range of serpentine (Lower Silurian No. III) east of the Missisco river, occurs in a vertical vein, traceable two miles, 4 feet wide and regular, free from admixture with serpentine and yielding peroxide iron 81.20, protoxide iron 13.37, titanic acid 4.10, silica 1.33 (metallic iron 66.62). In 1844 600 tons of pig iron were made of it.

The best known metamorphic iron ores of **Massachusetts** occur at Hawley in Franklin county in mica slate; two beds, ten feet apart, one magnetic oxide, the other a beautifully micaceous specular ore bed 2½ feet thick.[3] The partial deoxidation of one of these beds while the other remained saturated, may be hard to explain, but is an all-sufficient evidence of the non-igneous, that is, of the chemico-sedimentary nature of its origin. In **Connecticut** a few magnetic ore beds have been found in metamorphic rocks, but not exploited.

In **Northern New York, Essex and Clinton** counties contain the best known azoic or primary magnetic and specular ores. St. Lawrence, Franklin and Jefferson counties contain some of less importance. Prof. Emmons, Prof. Beck and Prof. Hodge have reported upon these officially or otherwise. In most cases they are massive layers of ore between gneissoid rocks

[2] See other instances Trans. Amer. Assoc. Geologists, vol. i. p. 251.
[3] Whitney, p. 460, Hodge, American R. R. Journal No. 684.

(altered shales and sandstones) always in the line of strike, but not always seeming to Dr. Emmons to be in the plane of dip.

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"Should I attempt to describe these masses (he says) I could convey an idea of them in no better language than to speak of them as ledges, cliffs or rocks of iron ore, exhibiting the same structure, natural joints or divisional planes as other rocks. Such is certainly the structure in the midst of the mass; but when the ore is situated near the rock, it gradually takes in a greater proportion of earthy matter or portions of the rock and perhaps becomes incorporated therewith; but at other times it sends off branches into the adjacent rock as in the annexed sketch."[5]

Dr. Emmons gives numerous figures to show the parallel arrangement of the crystals and lenticular masses of purer ore in the magnetic beds,[6] which can be best understood by recalling the bony and sulphurous layers in coal beds, all of them more or less lenticular in shape and showing how numerous and shifting were the nuclei or centres of formation, as the successive layers of the bed went on.—The specular ore occurs also according to Emmons in masses and in veins, both as a red powder and as a steel-bright crystalline mass.

The **Penfield** or **Crown Point** black magnetic **ore bed** in Essex county New York is 40 feet wide, in northeast striking gneiss (the middle is rich and pure,[7] growing lean with quartz towards the walls) for twenty rods as seen in 1840. At one point this great bed is 160 feet wide, a triangular mass of lean ore, the irregularity being in the roof-rock, the bottom being nearly horizontal. It is worked in an open quarry. The ore is free of sulphur and works beautifully in the forge. An extension perhaps of this bed quite similar to it has been opened half a mile south of it and another large vein of similar ore a mile northwest of it.

The **Schroon beds** lie west of the last described; one on the west side of Paradox lake, seven feet wide, very pure, very coarse and quartzose. Another on the other shore 18 inches wide dips into the mountain, like a trap dyke, a pure mass of magnetic oxide without admixture of earthy matter. In Warren county Hague township, in the Brant lake region, there is a north and south vein two feet wide, highly magnetic, fine grained, pure, dipping east, in hornblende. Three miles north

[5] Dr. Emmons gives figures (No. 21, No. 22) of the Adirondack mine on page 89 of part iv. Nat. Hist. of N. York. [6] New York Report, part iv., p. 242.

[7] Mag. oxide 92.97. silica alumina 5.93.—Dr. Beck.

of the lake, in Desolate, is a 10 feet vein fine grained and mixed with a little pyrites.[8]

The abandoned **Saxe ore bed** near the village of **Crown Point,** shows peroxide in the form of magnetic crystals, and is irregularly disseminated through the hornblendic gneiss. Its very color has changed to the reddish-brown limonite hue. Red ore is obtained at several other points near Crown Point and Ticonderoga to a small extent; in insulated masses, with gneiss and limestone at Shelving Rock, "four or five inches across, penetrating the strata perpendicularly for two feet and then disappearing." A large regular vein was opened four miles northwest of Port Henry, looking on the surface like a ferruginous trap.

The **Walton** or **Old Crown Point Vein,** two miles from Cedar Point has been open for seventy years; in 1840 it was 11 feet wide, and worked 30 feet deep and half a mile long; it dips 31° west conformably in gneiss; is black and friable, and makes tough iron. The joint of ore and gneiss is perfectly distinct.[9]

Half a mile below **Port Henry** the **Cragharbour vein** 12 feet wide (in 1840) dips 30° west under Hornblende Rock; black, tough, very magnetic, with feeble polarity; iron pyrites in thin seams but not disseminated; specific gravity 4.729; analysis, peroxide 64.80,[1] protoxide 24.50, silica, alumina, etc. 8.70, (Iron 65.23.) It is traceable for half a mile along the lake.[2] Hornblende is a constant impurity in this ore and is suspected of making it hard and brittle by Dr. Beck. N. Y. R. p. 14.

The two **Cheever veins** two miles north of Port Henry and a quarter of a mile back from the shore of Lake Champlain, are one 6 and the other 10 feet thick, dipping 30° or 40° away from the lake, and yielding a coarse but very pure magnetic oxide ore. A tunnel has been driven in from the lake shore to drain and work the beds.[3] Its associated minerals are hornblende, a little feldspar and sahlite or hypersthene.[4]

The two **Sandford beds** are four miles west of Port Henry, in the side of a hill a thousand feet above the lake. In 1857 the main excavation was 100 by 300 feet square and nearly 100 feet deep. The ore 60 feet thick plunged under a stratum of

[8] Emmons's New York Report, p. 234. [9] Emmons, p. 237.
[1] 66.80 in Dr. Beck's Report. [2] Emmons's Report, p. 236; see Beck's Report of 1837, p. 25. [3] Whitney, p. 466 [4] Dr. Beck, Report, p. 15.

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altered sand-rock 30 feet thick < 20°SW. At the NW end the ore terminates against a blank vertical wall, over which it is heaved, and settles in a thin layer (of 5 or 10 feet) at a gentle dip northwestward. At the southeast end there is no visible termination or diminution of the immense mass, which seems also to pass regularly down its dip as far as followed, under great arcades about as large as and more imposing than those supporting the Receiving Reservoir below the Boston State House. The other bed undoubtedly overlies the one just described about 100 feet (sand-rock between) and is itself irregularly 50 feet thick, dipping in the same direction down the little stream which drains its quarry. A gravity railroad is projected to Port Henry. This deposit is famous for its mixture with phosphate of lime, from the disseminated grains of which it receives a rich ruby tint. Expensive works were once put up to manufacture this manure to the neglect of the iron ore, and they have not been abandoned; but the mining of the ore has gone on rapidly increasing, and now it is sent to all the furnaces along the Hudson and to the furnaces and rolling mills of Ohio and western Pennsylvania, to mix with local ores and to line puddling furnaces. It is not adapted for the bloomary.[5]

The **Old Barnum vein**, half a mile west of the (Port Henry) Sandford vein was 7 feet thick in 1840, dipping 30° west, conformably, in hornblendic gneiss; black, soft, friable, pure.[6]

The **Hall vein** is a mile north of the Barnum, quartzose, dull black, 5 feet wide and dips 20° west *not*[7] conformably with the gneiss rocks, the walls showing slickensides. Masses of rock project across the vein as in coal mines where this effect is produced by pressure, and its appearance here argues for a soft condition of the ore at one time.[8] In one place a distinct anti-

[5] In the Sandford magnetic ore bed of Essex county, Mr. Wm. P. Blake has found the rare mineral carbonate of lanthanum, once found at Bethlehem, Pennsylvania, connected with the ores of zinc. Here it occurs in fissures of the magnetic ore mass, which is mixed up with reddish brown crystals of phosphate of lime (apatite), forming sometimes regular beds within the mass of ore itself, and apparently in greater abundance towards the top. Uncommonly large crystals of allanite are left sticking in the dark red feldspar granite wall of the mine when the ore is removed. Mr. Blake thinks the lanthanite here produced by slow decomposition of the allanite, and at Bethlehem by the decomposition of an isolated boulder of allanite.—*Silliman's Jour.* Art. xxxii., vol. xxvi., No. 77, Sep. 1950.

[6] Emmons, p. 238.

[7] Dr. Emmons's figure on p. 239 is very curious.

[8] Are figured by Dr. Emmons, fig. 63, p. 240.

clinal fold of ore and gneiss rock is exhibited. The Hall ore resembles the Penfield, and makes excellent iron. The Everest vein thirty or forty rods from the Hall vein and very dissimilar from it, although of the same size and dip, may be a different vein. Dr. Emmons could not determine the point to his own satisfaction.[9] The principal accompaniment of this ore is quartz, veins of which traverse it. Reddish feldspar of some beauty occurs also, and specimens of pyroxene, hornblende and crystals of phosphate of lime. In one of the veins of white quartz are brown zircons. A vein of pulverulent black matter (peroxide of iron?) traverses it.[1]

The **Everest Mines** and the **Everest and Green** mines are deposits of magnetic ore, showing the black magnetic ore unchanged in parts and in other parts changing or changed into red or specular iron ore.[2]

The **Adirondac Sanford bed** on Sanford Lake in Warren county and on the Adirondac river fifty miles from water navigation in the wilderness north of Saratoga was discovered by an Indian who revealed the fact to David Henderson of Jersey City in 1826 while standing on the wharf at the Elba works.[3] It is a magnetic ore bed called by Dr. Emmons 700 to 800 feet *thick*,[4] but so described by him and others as facing the mountain side, descending with the slope and "disappearing beneath the rock," that this measurement must of course be taken for the *breadth of its side exposure;* its thickness is entirely unknown and may not exceed 50 feet. It is a true rock deposit with a jointed structure cutting it up into large tabular masses, and its prolongation as a bed may be detected for several miles. Other beds occur in the neighborhood which may in the end prove to be upthrows or counter dips of this one. The ore is unequally oxidized and somewhat difficult of reduction. Two furnaces and very considerable works in the vicinity have as yet done nothing. The vein seems to appear again a mile and a half distant, 15 feet thick for 32 rods upon the surface, with all the characteristic features of the great bed.[5] It appears again on

[9] The Sandford beds are distinct, and these two Hall and Everest beds may be those.
[1] Dr. Beck, Report, p. 16.
[2] Dr. Beck, Report, p. 16.
[3] See Bulletin Am. Iron Ass. note 626, p. 165.
[4] Emmons's N. Y. Nat. Hist. part iv. p. 244; Amer. Geol. p. 93.
[5] Report of Adiron. Iron and Steel Co. 1854.

the opposite shore in the direction of Hill's island, disappearing under the water.

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The **Coarse Grained black vein** near the Adirondac works (in fact they are founded on the ore), is harder and more tenacious than the Sanford bed, and intermixed with hypersthene, labradorite, small masses of dark serpentine and here and there a nut of pyrites. The excavations cover ground 700 feet east and west by 3,168 feet (in 1840) north and south, the direction of the strike. As in the Sanford bed it is seen passing beneath rocks [and the whole may be considered a horizontal plate covered with patches of remaining rock]. Where wrought it shows 36 feet of pure solid ore unmixed with rock.

The **Fine Grained vein** is excavated 80 rods east of the works on a steep ridge and running northwest for 5,742 feet (in 1840) and very uniformly 150 feet in breadth [not in thickness but along the bevelled edge]. It is granular, buck-shot size or finer, firm, dull black and rich. Here and there is seen disseminated pyrites.[6]

Other veins are mentioned; one west of Lake Henderson, nearly a mile from the works, a beautiful fine-grained ore; another west of Lake Sanford, and a third east of the Sanford hill. These may be all parts of the same beds with those described.

Large masses of ore are seen on the East river waters brought down by ice. The **Cheney ore bed** west of Lake Sanford was discovered about 1841.

In **Saratoga and Washington counties** magnetic ore is common (as an injected mass Prof. Mather thinks) "spreading between strata of gneiss and communicating with larger masses like the trapean rocks." Darkbrown garnet, colophonite and coccolite are sometimes very abundant and even form by far the largest portion of the ore bed and frequently resemble the ore so closely that ordinary observers do not distinguish the true ore from these intermingled materials; as at the mine on top of the mountain four miles north of Fort Ann, where granular ore, granular black garnet, granular and crystalline hornblende are plenty and quartz in irregular roundish masses which "seems to have been softened by heat to assume the forms observed." The whole extensive ore bed would yield iron, but

[6] Emmons's N. Y. Report, p. 254.

is lean until picked. Several other beds in the same town near Mount Hope Furnace yield magnetic and sometimes polar ore sometimes pure, sometimes disseminated in gneiss, sometimes mixed with garnet, coccolite, hornblende, sometimes with limestone. Three beds southwest of the furnace send their ore on pond ice in winter to the furnace, which was the only high furnace in Washington county in 1842, but several forges on West Wood creek made anchors, etc. from pig or from Essex ore. Good ore is reported near **Comstock's landing**; north of **Dake's corners** Fort Ann; in **Dresden** south of Putnam's ferry; and a large body exists in the South Sacondaga mountain 2 miles south of **Hadley's falls**, examined and described by Mr. Seymour who reports 10 to 15 veins some of them 5 to 8 feet wide; the Porter vein he says becomes wider downwards and less mixed with its feldspar gangue, making a tough soft iron; it is nearly vertical and ranges due north while the strata dip 30° north-northwest and range east-northeast; the ore magnetic, 30 to 50 per cent iron; is owned by Mitchell, the Jefferses and Fay.[7] This description if correct looks more like ejection or igneous origin than anything we have. Just north of Jessup's landing, half a mile west of the Hudson, magnetic ore was discovered in 1826, and opened 20 feet deep and traced more than a mile in 1842. It is like the Duane ore, hard and tough, and makes a steely iron.[8] See page 397.

In **Westport** Essex county six miles west of the village on lot 177 a north and south vein of black magnetic ore 40 feet thick in granite, tough, rich and pure. Two other veins are known on lots 140, 141. An inferior vein has been opened 2 miles further north. Another 2 feet wide runs in hornblende rock northeast through lot No. 23, compact, tough. There are several others in Keene that do not promise much.[9]

Of the four **Arnold veins** in Clinton county the Old Blue vein yields from 2 to 8 feet of remarkably pure magnetic oxide (with a little silica) and was worked in 1842 260 feet deep and 1,300 feet along. All four veins lie parallel and have been heaved simultaneously by oblique trap-dykes, but not by the dykes which cross at right angles;[1] good evidence that the shift was due to a longitudinal horizontal strain and not to any earth-

[7] Mather R. p. 576.
[8] Dr. Beck's Report, p. 12.
[9] Emmons, p. 244.
[1] Emmons, iv. p. 292.

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quake or cataclysmic action. The veins dip 70° WNW, and probably extend beyond where ore of the same sort has been found half a mile along the strike.

The four beds are only separated from each other by a few feet of rock, the black bed being from 3 to 11 feet and the grey beds from 2 to 8 feet thick, the ore being the same in all, and the whole four may represent a quadruple coal bed or any other intermitted sedimentary deposit. The blue vein is at once distinguishable from the other three by its tint, and its iridescent and purple hues. Its streak is red, while that of the rock bed is brown. These are instances of the different degrees of oxidation either in the original deposit or in the beds subsequent to their present elevation. The other two beds are made grey by a grey quartz intermixture, but give a red streak and are brown on their weathered surfaces. All four beds being pure peroxides, yield a tough soft iron.[2] This ore Dr. Beck pronounces one of the purest and best known, and gives three analyses of three of the veins, as follows:

Black vein	protox. 27.00	perox. 71.50,	quartz 1.50;
Light blue vein (lime traces)		perox. 98.00,	silica 2.33;
Greyish vein, (mang. and lime)		perox. 97.00,	insol. 2.83.

Dr. Emmons discusses at great length the causes of the easy fluxibility of this ore and Mr. Clay's process of doing it.[3]

The **Finch vein** is a continuation of the Arnold, and gives grey and black ores.

The **Palmer veins** three miles west of the Finch, were not opened as to the principal 35 foot vein until 1839. They resemble the Arnold veins, but run in more crystalline rocks, with large masses of feldspar and quartz, and a little mica disseminated.[4] Dr. Emmons calls it a bunch of magnetic ore 35 feet wide, without distinct walls, gradually passing into altered sandstone at the edges and much mixed up with sand (quartz) throughout, requiring washing.[5] The ore is black magnetic and is not only washed but separated by magnets for furnace use. The history of the working is curious. For a long time a great dyke hid the main deposit from the levels which were taking out a lean rock ore, got between smaller dykes. On the point of abandoning these uncertain workings the owners determined to

[2] Emmons's Report.
[3] Pages 293 to 299; see hereafter.
[4] Dr. Beck.
[5] Report, page 299.

at least cut through the main dyke (14 feet thick) and on doing so broke into the solid ore, which did not show itself on the surface and could not have been in the least suspected to exist at this trifling depth (see Dr. Emmons's diagrams). The dissemination of the ore through the barren ground is a fine illustration of the chemico-sedimentary origin of such veins even when in the presence of their so-called generators the igneous dykes. If the great dyke here generated the great ore bed at one point it would have at another; if on one side it would on the other.

The **Cook veins** traverse a hill three miles northwest from Clintonville, a 2 foot and a 13 foot bed, parallel and four feet apart; three other veins also parallel 6, 3 and 2 feet wide; ore black, granular and soft, or compact and firm; strongly attracted and polar; gangue quartz, black mica and hornblende, intimately mixed with the ore which is separated by magnets, and yields good iron.[6] The 14 foot bed was discovered by Mr. Cook (when the Pennsylvania Company abandoned their vertical 2 foot bed at a depth of 50 feet) driving across the measures. Only 5 feet of wall separated the workings from this magnificent treasure for many years! The four veins with an aggregate width of 24 feet, can be worked together. The large vein forms the backbone and crest of ridge and can be traced for a mile and a half north and south. It is a rich vein at the surface, and Dr. Emmons says the veins improved downward both in width and freedom from quartz. "The arrangement of the ore and earthy matter is mostly in vertical parallel bands or stripes."

The **Stone mine** is at the north end of the Cook vein outcrop. In describing this ore Dr. Emmons notices the fact that pieces of it raised from a depth of 25 or 30 feet showing neither polarity nor magnetism acquire it afterwards strongly by exposure to light and air. These veins are traversed by various dykes apparently parallel N. 50° East.[7]

The **Battie vein**[8] is also a part of the Cook, distant one and a half mile and connected by an outcrop. The southern opening and eastern wall ore is largely mixed with pyrites. Twenty rods further north the vein was reopened 14 feet wide, mixed with flint, hornblende and black mica, with thick, solid wedges of non-pyritous ore. The four or *five* Cook veins are here only

[6] Dr. Beck, p, 19. [7] Emmons, p. 302. [8] Printed Baltic in Beck's Report.

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two, dipping very steeply to the eastward, almost vertical, and fifteen rods further west is a *third* vein 5 or 6 feet wide, with a gangue of pure white flint with one-third its bulk of black ore.[9]

The **Rutger vein**, eight miles west of Clintonville is 10 feet wide, parallel to the Cook and Arnold, and occupies like many others the crest of a primary ridge; is lean at the surface, with a very peculiar gangue, "like phosphate of lime," but undescribed by either Dr. Emmons or Dr. Beck. Its ore had been abandoned in 1840.

The **Winter vein** is drawn on Emmons's Section, page 306, as occupying a fourth or westernmost ridge, next west of the Cook, and described as a horizontal outflow of lava-like metal forty feet in one direction by one hundred in another, unequally distributed, but nowhere more than 2 feet deep as pure ore. But in fact this bed differs from others in no respect except in its nearly horizontal posture, and in this it resembles the Sanford beds at Port Henry and at Adirondack. "It presents the same general arrangement as all other veins, that of parallel bands or stripes." Its dip is actually west and it is traversed by at least nine dykes of various width but all parallel to one another within the hundred feet. The rock on which this ore-floor rests has ore disseminated through it.

The **Mace vein**, 4 feet wide, dipping west, traceable 30 rods, rich, but flinty, was lately discovered (in 1842) two miles east of Clintonville.

The **Burt vein**, 8 feet wide, striking east and west, is tough, granular, pyritous, feldspathic, the ore distributed in masses of several pound's weight.

The **Jackson vein** was considered by Emmons a continuation of the Arnold, like the Finch.

The **McIntyre vein** is different from the Palmer although in the same hill, but on its south face and striking northwest. Its width varies from 6 to 10 feet. It is non-pyritous, associated with black mica, hornblende and quartz and promised to be a large and valuable bed in 1842.[1]

The **Skinner vein**, 20 miles west of Plattsburg and 7 northwest of Cadyville, an important vein, cutting very coarse red

[9] Emmons, p. 303.

[1] Emmons's Rep. p. 307.

granite, black, quite pure inside, outside mixed with decomposed feldspar, is coarse and easily prepared for the furnace, slightly magnetic and of a dull lustre. It is mixed with hornblende and a little phosphate of lime (?) but makes a tough iron.[2]

The **Sailly and Averil vein**, situated about three miles north of the Saranac river in the forest, yields a valuable, fine-grained, bright, somewhat sulphurous (and pyroxenic?) ore, breaking into angular masses and containing one-third earthy matter, lies in coarse red granite in which large crystalline masses of feldspar are common. It may be a continuation of the Skinner Vein.[2]

In **Franklin County** the magnetic veins are not so numerous, probably because the primary mountains around Mount Seward form an uninterrupted belt 50 miles wide against which the palæozoic rocks lie in a belt only 10 miles wide from north to south. It is a country of mountain lakes and rocks of the Huronian and Laurentian system far too low for the ore deposits which occur not far beneath the Potsdam sandstone.

The **Miller vein**, in a hill in Franklin township near the falls of the Saranac, is the southernmost known to Dr. Emmons; fine-grained, pure and rich. A similar vein was found on Chub river. A vein of black ore was reported at Tupper's lake.

The **Conger veins**, near the Port Kent and Hopkinton road in T. No. 11, is a group of coarse-grained, black, bright ore-beds intermixed with decomposed feldspar and white flint, in gneiss (with hornblende and black mica). Four or five miles distant others were discovered.

The **Deer River vein**, near Duane and three miles from the Deer River Furnace, is 20 feet wide, with regular walls, well defined, strike east-northeast, traceable as a great bed 80 rods, ore mostly protoxide, strongly magnetic, sometimes polar, lustre resinous, shining and also dull, fracture angular, along cleavage joints coated with green earth and yellow oxide, ore mixed with hypersthene, vein traversed lengthwise by seams of light colored feldspar, hornblendic, gangue principally coarse hornblende with large garnets and some black mica, iron made soft and tough for castings.[3]

Another wide vein of magnetic oxide has been opened on a high hill by James Duane.[4]

[2] Emmons, pp. 307, 308. [3] Emmons, p. 328. [4] Emmons, p. 328.

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The steel ore bed, four miles east of Duane Furnace on a steep hill 500 feet high, dips east, is from 1 to 8 feet wide disturbed by trap dykes, walls broken, gangue hornblende with quartz and feldspar, ore coarse and fine with more hypersthene than the Deer river ore (the hypersthene looks like bronze), sometimes iridescent, a very little pyritous, with small masses of feldspar and garnets, fracture angular. The Franklin ores Dr. Emmons thinks to differ from the Essex and Clinton in being so hornblendic.[5] This ore although called locally a steel ore is a common magnetic oxide, but makes a fine grained pot metal of more than ordinary strength on account of the mixture of bar iron made out of the peroxide while the protoxide part of the ore becomes a kind of steel. Hematite ores, such as Scotch pig is made of, produce a homogeneous and therefore brittle cast iron. Duane ore, cast into chisels, plane irons, knives, etc. and tempered in oil, makes a useful metal but not to be depended on like well made steel. The proper treatment of mixed ores like the magnetic is to stamp and separate the magnetic grains by magnets before forging.[6]

The **Malone veins**, four miles west of Malone, run in parallel lines obliquely across the axis of a granitoid ridge, and more westerly than common, through a decomposed rock. They were abandoned before 1842 and are the most northerly of all the primary magnetic veins.

In **St. Lawrence County** the magnetic ores scarcely appear. At Pierrepont a bed has been wrought and ore found at Canton. In this county the primary ores are almost all *specular* or peroxide.

The **Parish mine** in Gouverneur is almost pure peroxide, containing only 2 or 3 per cent of sand. Beck describes it as a

[5] Pyroxene and hornblende sometimes contain a very large percentage of iron in both its forms of pro- and sesqui-oxide. See the list of analyses in Amer. Journ. 1858, p. 353, one of which (10 b.) reads: $\ddot{Si}$ 40.00 $\dddot{\overline{Fe}}$ 10.45 $\dot{Fe}$ 13.38 $\dot{Ca}$ 11.28 $\dot{Mg}$. 7.51 $\dddot{\overline{Al}}$ 7.37 $\dot{Na} + \dot{K}$ 5.25 $\dot{Mn}$ 1.85 Fl 1.07 ign. 0.54 = 98.70. The new conclusion (mineralogically considered) to which Rammelsburg arrives is the *common* bisilicate structure, or oxygen ratio (1 : 2) between the bases and silica, of the hornblendes and pyroxene.* The quantities of iron vary extremely in these rocks, and is quite sufficient to account for the segregation of vast beds of ore.

[6] Emmons, p. 330. Dr. Beck gives T. B. Clemson's analysis as follows: Iron and scoria 15.42, Iron alone 12.90, Part possessing the properties of steel 64.50.—Rep. p. 20.

* Dana, Amer. Jour. 1858, p. 353.

flat bed beneath the Potsdam (and therefore nearly in the same geological position with the magnetic ore of Cornwall and Warwick and the brown hematite ore of Chestnut Hill in Eastern Pennsylvania), but Emmons sees in it an eruption pitching the sandstone both ways.[7] Venuxem (to whose genius we are indebted for so many fine truths in American geology, and among others for the first correlation of the New Jersey green sand with the corresponding cretaceous rocks of Europe) saw the impossibility of this and suggested a chemico-sedimentary explanation of the striking difference between these specular ores and the magnetic ores of the neighboring counties. He makes the specular ores local deposits of peroxide of iron (bog ore) on the primary surface subsequent to its elevation and denudation and just before or during the first deposits of the Potsdam sandstone; and in connection with the chemical precipitation of limestone. He says, "it seems to have separated from the limestone by crystalline action, like gypsum and other minerals, being frequently enveloped in limestone. Where found it is but a superficial mass; and though its matrix is mixed with primary rock the origin of the two was subsequent to that rock, appearing to have been local deposits of calcareous marl and oxide of iron similar to those met with in the gypseous region; the marl and oxide separating from each other by crystallization, being placed in a position which facts elsewhere prove was highly favorable to this operation." "At Lewisburg the same limestone and specular ore, the supposed associates of the primary rocks, intermixed with red ore, prove a connection with the Potsdam, as intimate, if not more so, than could be discovered for the primary mass." [8]

Dr. Emmons was disturbed by this opinion because, as he said, "admitting the theory, we may just as well admit that all the beds of primary limestone and veins also were deposits in the form of marl or tufa, for they are all alike," an admission which he has refused to make down to the present time. He also asserts in his Report that "most of the beds of specular oxide, as the Tate and Polley beds or veins, are wholly disconnected with this rock; they are contained in gneiss; they are wholly mined in gneiss and are not taken off from the primary

[7] Whitney, M. W.

[8] Geol. III. Dis. p. 267.

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surface as though they were deposited upon it." But the fact is that the gneiss is but a previously deposited part of the Potsdam sandstone, or that first and opening formation of the Palæozoic system, or which is the same thing one of the later deposits of the immediately preceding Huronian or Azoic system. It is not certain that Vanuxem thought of bog ore deposits, nor of the primary floor in any other sense than the last receiving bed prepared for the Potsdam sandstone.

Many of the **Parish and Kearny beds** are in the form of red stony matter (says Emmons) passing into powder and very unlike crystalline specular ore, being large masses descending into the primary rocks. [They are probably like the brown hematite masses which descend into the Lower Silurian rocks, and were so conceived of by Vanuxem.] "I was unable to find lateral walls or the precise extent of the masses on either hand." The southern angle of the Parish mine rested on serpentine and serpentine is often seen in the midst of the ore, [a sufficient proof that both were imbedded, and that the ore is a decomposition from the gangue rock that held them in common, or rather the iron from the decomposed part of the serpentine mass.[9]]

"In most of these beds of specular ore we find large masses of the primary rocks, mostly of a silicious kind. Besides these subordinate veins and masses of the carbonate of iron, fine geodes of quartz crystals are not uncommon. Sulphuret of iron both in a state of proto-sulphuret and persulphuret occurs in most localities; the former disseminated, decomposing and passing into sulphate of iron; the latter in crystals and more permanent in its form." "Besides the powdery and massive forms of the ore, it is often in fine lenticular crystals or fine brilliant scales, the *micaceous oxide*, resembling graphite," "also in mammillary and tuberose forms as in the hematitic beds."[1]

The **Kearney bed** of specular red oxide lies about 40 rods northwest of the Parish bed and is evidently a continuation of it, the Potsdam sandstone dipping south of the one and north of the other, the serpentine or ore between, upon the anticlinal, but "no igneous rocks as trap or greenstone seen in the vicinity."[2] The specimens from the Parish and Kearney beds

[9] A slaty serpentine and a fibrous serpentine (*Metaxite*) from Tyrol gave v. Gilm Ḟe 5.71 and 5.98 in its silicate of magnesia mass.—T. Hunt *in Amer. Jour.* 1858, pp. 358 and 234.

[1] Emmons, p. 345.

[2] Emmons's Report, New York, p. 93.

are slaty like the micaceous ore; hard and compact; jaspery and semicrystalline, etc. Associated with the ore are crystals of brown spar, carbonate of iron, calc spar (dodecahedral crystals) rarely sulphate of barytes. The most abundant ore is dull brown red, compact, earthy, peroxide iron 96.52, silica, alumina, etc. 3.40, and when selected yields 50 per cent pig iron.[3]

The **Edwards' specular ore** mass in primary limestone seemed a north and south vein 3 or 4 feet wide, but it soon narrowed and disappeared over serpentine and a yellowish lean carbonate of iron. A tunnel crosscut discovered nothing but a few sporadic masses. Dr. Emmons compares the Troy mine in Vermont of magnetic ore in serpentine, ten feet wide at the surface and running out like this.

The **Tate and Polley specular veins** are near each other but disconnected, on two opposite sides of a gneiss hill, and dip 70° northwest. The Tate ore is bright red resembling the Parish. The Polley ore is quartzose and leaner. No Potsdam or any other [unchanged] sedimentary rocks are near.[4]

Another specular oxide vein is opened three miles west of Dekalb village, in gneiss and not near Potsdam sandstone.[5]

The **Theresa specular** red oxide beds "are arranged in indistinct layers in the Potsdam sandstone; these layers appearing to have been originally this sandstone only, but subsequently filled or saturated with the oxide of iron, some of which if found in any other place, as in boulders, would have passed for quartz highly charged with iron."[6]

The **Fowler specular** lean ore "is a red rock apparently stratified, lying between layers of gneiss, over which the sandstone (Potsdam) partially projects. The mass of ore is not therefore interposed simply between the sandstone and the gneiss."[7]

The charcoal furnaces of New York that use magnetic ore are Mount Hope (K 627) in Washington county; Crown Point (K 628) in Essex, and Danemora (K 629) in Clinton county.

Those that use the red oxide are Rossie and Fullerville (K 631, 634) in St. Lawrence; Redwood, Wegatchie, Sterlingburg and Sterlingville (K 632, 633, 635, 637) in Jefferson; Sterlingbush and Alpina (K 636, 638) in Lewis county.

Those that use the fossil red oxide of the Upper Silurian formation are the seven in Oneida, Oswego, Chenango and Wayne counties and need not be here specified.

[3] Beck, p. 25.
[4] Emmons's Rep. p. 347.
[5] Emmons's Rep. p. 347.
[6] Emmons's Nat. Hist. N. York, part iv. p. 94.
[7] Emmons, fig. 28, p. 95.

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The bloomaries of the Champlain district, viz. two in Washington, sixteen in Essex and eighteen in Clinton, use magnetic ore like the furnaces of that region.

The two bloomaries of St. Lawrence county use a lean bog ore near Brasher's falls; the six remaining forges of the St. Lawrence district, having no magnetic ore, and not being able to work up the red oxide, mix furnace pig and scrap iron.

The mines of magnetic ore in Moriah, Washington county, supply the West Fort Ann bloomaries and Mount Hope furnace which gets half its stock from the Cheever (53 per cent) and half from its own neighborhood.

The Penfield bed (55 per cent ore) five miles west of Penfield forge in Essex county, supplies that and Schroon forge and Crown Point furnace; Schroon forge is also supplied from a 35 per cent magnetic ore bed in the northeast corner of the township, seven miles off (4 tons ore to 1 ton metal), costing at the forge $5.25. Two other bloomaries are on Schroon river, North Hudson and Deadwater.—Noble's forge at the outlet of Black Pond uses half Sandford half Haasz's ore (4 miles southwest). New Russia forge uses half Barton ore from Moriah township, and half from a bed two miles west; and three other bloomaries on the Bouquet river, Elizabethtown, Westport and Whallonsburg, do the same. Wilder's and Merriam's forges on the north branch of Bouquet river, use the North American company's magnetic ore from Moriah, 50 per cent, $7 washed and delivered. Willsborough forge on Bouquet river two miles west of the Lake uses Barton ore, alone, brought from Moriah, 3 tons of which makes 2 washed and 1 iron. Highland forge at the outlet of Warm Pond one mile west of the lake uses Goff's magnetic ore from Moriah. Purmort's forge on South Ausable uses Arnold's magnetic ore in Ausable township, 4 tons of which (washed 2) produce 1 of iron. Ausable forge on the west branch as well as the Upper and Lower Blackbrook forges in Clinton county use Palmer's magnetic ore in Blackbrook township, two miles from Ausable village, 4 tons = 2 separated = 1 iron.

In Clinton county besides the two just mentioned, the New Sweden forge in the North Ausable mixes Jackson's and Nelson's ores, 3 miles distant, and so do the two Clintonville village forges, two miles on the same stream. Cook's forge in Cooksackie is stopped. Honsinger's in Peaseville uses Tremble's magnetic ore from Saranac river. The two Norrisville forges 2½ miles west of Schuyler's falls of Salmon river use Goff's and American company's ores from Moriah. Merchant's is also on Salmon. Myers' forge on west branch south Saranac has its own magnetic ore directly opposite, lean but good, 5 tons = 2¼ separated, making one ton of iron of the best quality, used for wire, axles, etc. The Russia forges on Saranac also use Tremble's ore, 3 miles southwest opposite Redford, and mix some Amer. Co. Moriah ore. Platt's forge in Saranac village mixes with Tremble's and A. C. ore also Sherman's and Goff's, of which 2 tons washed make one of iron, 300 bushels charcoal to a ton of metal. Elsinore forge on the north bank of the Saranac mixes Amer. Co. and Sherman ores. The Danemora forge has its own 50 per cent magnetic ore bed in the inclosure of the state prison, with the furnace. Stone forge, on the south bank below Cadyville uses the same ore. Weston forge in Plattsburg brings its ore from Moriah.*

In **Putnam, Orange and Westchester counties** New York, the metamorphic rocks contain numerous deposits of mag-

* J. Lesley, jun. in the Bulletin of the Amer. Iron Assoc. Phila. May 1, 1858.

netic ore which were examined and reported upon during the progress of the State Geological Survey by Prof. Mather and also by Prof. Beck, who thought them as extensive perhaps as any in the world, yet as late as 1849 but two blast furnaces used them in making iron. Surrounded as they are by mountains covered with timber (although at a distance from mineral coal regions), and so near the actual commercial metropolis of America, there can be no explanation offered for this apparent lack of energy applied to a great national necessity, but the perpetual malignant and omnipotent counteracting vigilance of a foreign interest unrestrained by any wise, self-protecting policy at home; an interest which has stationed its police upon the New York wharves, and as it were its spies at the mouth of every ore-drift and tunnel head. Establish some shore defences against the sudden and skillful blows of this foe, and Whitney well says,[8] "It is difficult to see what drawback there can be to the future prosperity of this region, situated as it is."

The following mines **in the New York Highlands,** east and west of the Hudson river, are described by Prof. Mather in his Report of 1842, from page 559 to 576. Magnetic ore is the only ore of any economical importance and is confined to the Highlands, and abounds in Putnam county. Lead, silver, tin and copper pyrites, and carbonate of copper occur in insignificant quantities in the same rocks, and beds of pyrites with gypsum and sulphate of alum.[9] The magnetic iron-ore masses are beds in pure or in hornblendic gneiss, which on careful investigation Prof. Mather felt himself constrained to consider true veins, although their course is parallel with the strike and the dip of the rocks, for by close examination he thought he found out that at certain distances they broke from this order and crossed the strata, to resume a parallel plane again beyond. "At some places where a great bed of ore occurs at some depth, only a few small stripes of ore penetrate through the superincumbent mass to the surface, as if the rocks had been cracked asunder and these small seams of ore had been forced up from the main mass below. The beds of magnetic ore lie either vertical or dipping to the southeast at an angle corresponding to the dip of the strata. One example only was observed where the dip was to the west-

[8] Whitney, p. 465.

[9] Described in his report, pp. 114, 119.

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northwest, viz., at the Stewart mine. The ore is very variable in quality. In some it is nearly pure, in others intermixed more or less with the materials of the contiguous rocks, in others mingled with pyrites and some other minerals."

On **Breakneck Mountain** in Putnam county east of the Hudson, several tons had been mined from an unexplored vein.

On **Constitution Island** opposite West Point foundry a bed was opened at the northeast end and another in the centre, the ore disseminated through gneiss.

East of **West Point** a mile and a quarter, magnetic ore is disseminated through limestone for three miles northeastward to within half a mile of the Cotton rock.

Northeast of **Anthony's Nose** (a bold promontory on the Hudson) a mile, at the "old silver mine" a mile southeast of Conshook island, magnetic ore with augite and limestone occurs in "granite." On the Nose itself a bed of it was opened many years ago but abandoned on account of pyrites and phosphate of lime. A mile east of its western summit, in the brown spar of the White mine, magnetic ore is disseminated.

The **Tilly Foster bed**, three miles southeast of Putnam courthouse, is a ridge of ore, 30 feet high, 300 long, and from 10 to 40 wide, associated with serpentine, limestone (containing brucite or boltonite), and green mica, with a wall of gneiss on the east and serpentine, limestone and verd antique on the west. Half a mile southeast some tons were found mixed with manganesian garnet, augite and hornblende.

The **Simewog hill ore** of **Townsend's mine** in Southeast town, Putnam county New York is the oldest known in this region, having been carted to Danbury Connecticut and places on Long Island Sound, but was abandoned about 1820 after 50,000 tons had been taken out here, and 100,000 further along the outcrop on the hill. Mather calculated in 1842 that a million tons were still above the water level of the Croton river. The vein was traced a mile and a half, and probably runs on a mile further south-southwest.[1] When crossed by a run, the vein is from 8 to 14 feet thick and nearly vertical, between gneiss and hornblendic gneiss walls, dipping 70° to 85° east-

[1] The compass variation at Mr. Wood's house is described by Mather to be 30°—40°, page 114.

southeast. On Simewog hill it is 20 feet thick between the same rocks and granite, and sunk on 30–60 feet deep for 3 or 400 yards. Mather's fig. 12 plate 5 represents it as an igneous outburst crossing the strata obliquely just where it reaches the surface, which is extremely improbable.

The **Phillips vein** in Putnam county, has been mined along the east ridge of the Highlands[2] at intervals for eight miles in many places. Dykes and faults cross it. It crosses the Coldspring and Patterson creek turnpike nine mile from Coldspring-landing near the crest of the mountain, and seems here to be injected in little sheets, veins and beds through the gneiss, so as to form from one-fourth to three-fourths of the mass through a thickness of 30 or 35 feet vertical strata. Pyrites abound. The ore may be traced by black bands in the rock. A quarter of a mile southwest 500 tons spoilt by pyrites were thrown out to slack. Further on, the ore and rock, mixed, measure 10–20 feet, in gneiss and hornblendic gneiss, dipping 60° east-southeast. Then comes the upper main Phillips line, more or less pyritous. The lower mine has a solid rock roof, is 15 to 20 feet wide, and 30 to 40 feet deep. The ore here is nearly pure magnetic, compact, in a rock mostly pearly grey wrinkled feldspar with some blue quartz; hornblende is also common. From this opening 20 to 30,000 tons had been taken out previous to 1842, and 3 to 5,000 from other openings half a mile further on southwest. Other openings further on bring us to

The **Stewart mine,** on a continuation of the Phillips vein, composed of 12 feet pure and 4 feet lean ore, the former used by forges, the latter by furnaces.[3] "The ore here is purer than

[2] This topographical fact is sufficient evidence of its non-igneous and truly sedimentary origin. A crack in the crust of the earth coming up just along the crest of a mountain for eight miles is an absurdity, not to be discussed. Were it a vein of solid iron a thousand or even a hundred feet thick, then it would act topographically *after ejection* like a massive sandrock rib, and form the backbone and crest of a mountain. As the case stands it must be even *topographically* looked upon as an accidental element of the massive metamorphosed rocks which form the rib and crest of the ridge. Viewing them *chemically*, Dr. Beck did not fail to recognize the same fact, for he says, "there are here apparently three distinct deposits of this ore, scarcely differing from each other, except in the proportion of iron pyrites which they contain. However much they may resemble veins when on the surface of the rock, wherever they have been opened to any extent, they are found to be parallel with the general stratification."—*Report*, p. 11.

[3] In 1842 Mather reports the Coldspring Furnace and Bonnell's Forge at Phillipstown as the only works left in working order in the counties of New York, Westchester and

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that of any mine I have seen;" granular, easily broken and crumbling into shot. The mine is on the east slope of the mountain one or two hundred feet above the marsh and in feldspathic gneiss dipping 70° west-northwest. Half a mile south-southwest is another opening in lean ore mixed with gneiss. Three-fourths of a mile further on is

The **Denny mine,** on a prolongation of the Phillips vein, on one of the crests of the mountains half a mile east-northeast of Warren's Tavern in Phillipstown. Ore compact, pretty pure, but often largely silicious, strongly magnetic, polar, easily powdered, black, analyzing 89.00 mag. ox. 11.00 silica, etc. and associated with silica, feldspar and rarely carbonate lime and asbestus. The vein sometimes shows in parallel stripes on the surface of the rock; at others large masses exist below with no out-show, and the vein sends strings into the walls from ⅛ to an inch thick. The solid ore in the mine in 1842 was 25 feet wide, and two hundred yards southwest is another opening 60 feet deep and 20 to 30 wide from which 20 to 30,000 tons had been removed in 1842. A third opening 30 feet deep to water level shows the vein split by a rock-horse 5 feet thick.

The **Coalgrove mine** is a mile further on, on a narrow vein, in gneiss, 4 feet wide twelve feet beneath the surface; ore rich and right for the forge.[4]

The **Gouverneur mine,** is two miles further on and 4 miles east of the Phillips manor house, opened along the crest of the mountain to a depth of 5 to 20 feet, vertical, ore disseminated in gneiss and granitoid rock. Between this and the Coalgrove mine **titaniferous magnetic ore** disseminated and in lumps occupies a gangue from 6 to 12 feet wide.[5]

The **Theall vein** midway between Croton Falls and Brewster's Station on the Harlem railroad, which at one point passes within a third of a mile of the main bed of ore, is thus described by Dr. Deck of New York in 1856: "It is found in the northern face of a hill or bluff, a spur or offshoot of the Simewog mountain, about sixty feet high in the vicinity of the present opening, and gradually rising to an altitude of about six hundred, in the length of half a mile, running nearly due south.

Putnam. The Furnace ran on Phillips & Denny ore, east, and Townsend's Canterbury and O'Neill's Warwick ore, west of the river.—MATHER p. 546.

[4] Mather, p. 563.

[5] Mather, p. 564.

This spur or hill is of granitic gneiss, but where the ore comes in immediate contact with the walls or sides, it is hornblendic, and highly charged with particles of the magnetic oxide; the course of the vein is N12°E, S12°W. The inclosing rock has nearly the same dip as the ore vein itself, about 72 degrees. . . . The vein in its descent after 40 feet, undergoes a slight change to a more vertical angle, and will probably continue to increase thus at greater depths. It is first exposed about twenty feet wide in an open cut, from the surface down about eight feet; here it is much mixed with pyrites and hornblendic gneiss, but improves in its width and quality at every foot in descent, and at water level about 45 feet from the surface, presents a clear unbroken face of superior ore from 25 to 35 feet wide, and continues to increase in richness and width about 1 foot in 3; the accumulation of water can be readily overcome by the eligible position for draining into the valley below. There is at present shown a breast of ore 70 feet high, and from 30 to 40 feet wide (exclusive of the dykes), and extending into the whole length of the hill; this, as far as computation may be made upon the quantity of ore, from its area and specific gravity, will give an estimate of several millions of tons. About 2,000 tons have already been mined. The entire width of the vein has not yet been arrived at; there are dykes or protrusions of the rock cutting the vein obliquely, and assuming a wedge shape in their descent, which I am firmly of opinion thin out at certain depths, leaving the vein below in one unbroken width.

"I observe in the entire width of the opening now exposed, four apparently large veins, intersected by as many dykes, plainly visible; two towards the west, one in the centre, and one easterly. These four, I doubt not, will be found continuous in a solid vein upon further excavation, at a moderate depth. My opinion is, that these dykes being of the same material as the surrounding rocks, the splitting up and intrusion of them arises from the anticlinal axis formed by the upheaval, subsidence, and consequent dislocation of the range in which they are found, and which places the parts of the veins by folds, in the strata, in such relationship that they appear to be more than one vein; but until further and deeper explorations be made, this opinion must remain as a hypothesis. On the easterly edge of the vein, the dyke has been cut through to a thickness

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of two feet, and exposes a mass of ore of the richest quality, and bidding fair to be very extensive; the width by the variation of the compass, showing over seven feet, again intersected by another dyke. And on the western slope, though the ore is thinner and leaner, the same indications present themselves. . . . .

"I have made a careful analysis of samples of the ore taken by myself from about forty feet depth on the vein, and consider it a fair average sample of the whole vein now exposed. The best and lowest ore is highly magnetic, sometimes polaric, of a greenish-black color and streak, disposed in columnar or tabular masses which readily break in one line of cleavage, crystalline, or more properly pyrocrystalline in its structure, and in its most compact state is met with at the lowest part, is very unchangeable in its composition; at the surface it is dense and somewhat interspersed with pyrites or sulphuret of iron, but gradually loses it, so that at a depth of forty feet it is scarcely visible even by a lens. . . . .

"*Analysis.*

Protoxide of Iron,	26.30	Metallic iron,	Oxide of Manganese,	.75
Peroxide of Iron,	57.00	59.80	Sulphur,	1.20
Silica,	13.10		Phosphate of Lime,	.40
Titanic Acid,	1.25			
				100.00

Traces of Copper and Zinc. Specific gravity 5.078.

"In conclusion, I would note, that in applying the term 'beds or deposit' to this ore, I allude to its present aspect as qualifying the expression; but when the walls are reached on either side, its characteristic features as a vein will fully develop themselves, for there is no doubt whatever that these iron accumulations are *true veins*, and are thus connected with larger masses below of an unknown width and depth."[6] . . . .

Dr. Deck's opinions and description are irreconcilably at variance in this instance. His "dykes" are parallel partings in the bed; he says himself they are of the same character as the wall rocks. Of course they are no dykes, but interval sediments. He has no ground for supposing that they will run out as the bed or beds of ore are worked downwards, except the interest of the Mott Haven (A. M. I. C.) company to whom he pre-

[6] Report to the American Magnetic Iron Company, 1857.

sents the report. If one or other of them thin away by virtue of the lenticular structure of all such partings, one or more will lap in to take their place, as described in other mines of this range, and as in the case of all sedimentary partings in all kinds of beds. The sections given in the Prospectus of the company in 1856, although unskillfully drawn and therefore not agreeing at all with each other, show this ore bed as a regular top layer curving over conformably with the other rocks of the hill along its surface. The bed is no "true vein" by its own showing.

Crossing the Hudson River into **Orange and Rockland** counties the Highlands carry forward their gneissoid rocks and veins of magnetic iron ore towards New Jersey. Most of the mines, says Mather,[7] are on three or four lines which extend across the counties from northeast to southwest, sometimes continuous and sometimes heaved to the right or left.

Butter Hill mines, Deer Hill mines, Clove mine, O'Neil mine and the Forshee mine, seem to lie along a line following the northwest face of the Highlands. The veins on Constitution island above described prolonged southwestward seem to open at the new West Point mine, Meek's, Krankheit's, Forest of Dean, Greenwood (or else the Hassenclever), Patterson, Mountain, Long mine, Crossway, Stirling mine and another on the New Jersey line. A third range seems to start at the north side of the Crow's Nest at the Round Pond mine; and a fourth from Fort Montgomery by Queensbury mine and Rich mine; both run into New Jersey.[8]

At **Fort Montgomery** lower-landing magnetic ore with much pyrites, or in a gangue of pyrites, occurs, and magnetic sulphuret is said to be abundant.

The Consook island-neck vein may be continued past the ores on the Fort Montgomery and Haverstraw road and Haverstraw and Queensbury road, and thence up through the Tymp or gorge between the Bear and Dunderhead.

The **Queensbury** Furnace is said to have an ore bed near it.[9]

At **West Point** a bed of magnetic ore occurs 200 yards east of the reservoir, with hornblende, and traceable towards

Meek's mine on the west part of Bear Hill southwest of Buttermilk Falls where the ore is titaniferous.

[7] Report, p. 565. [8] Mather, p. 565. [9] Mather's Report.

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Kronkeit's mine is three miles from Fort Montgomery and five miles southwest of West Point and has a double bed, divided by a sheet of rock, the ore beds varying from a few inches to 10 feet in thickness, dipping 70° west-northwest, and traceable eighty rods north-northeastward. About 1805 or '10 800 tons of superior ore were taken out.[1]

Round Pond mine, a quarter of a mile northwest of the pond yielded many years ago pure forge ore. Near the north-east end of the pond another was opened afterwards.[2]

Smith's mine, opened in 1828 and abandoned before 1842, lies between Crow's Nest and Butterhill, two miles from Kronkeit's landing, 4 feet thick, dipping with gneiss, and strongly magnetic.[3]

The **Forest of Dean mine,** three miles southwest of Kronkeit's and six west-northwest of Fort Montgomery, belonged to G. Ferris in 1842 and had been worked many years.[4] This vast bed, 150 feet broad, for 70 feet down the dip (40°–60° east-southeast) between gneiss, said to be solid ore, had yielded up to 1842, at least 40,000 tons from an open quarry which was abandoned on account of imperfect drainage. A peculiar associated granite "seems to form imbedded and capping masses to the mass of ore."[5] Dr. Beck says the vein is from 30 to 36 feet thick; the ore attracted by the magnet, usually free from sulphur, making cold-short iron when unmixed but good bars and castings when mixed with ore from the neighboring mine. The same bed perhaps appears two miles up the stream.

The **Queensborough mine,** is an extensive and long-wrought mine near the last.

The **Green and Titus Deer Hill** Canterbury mine yields granular, friable, good ore, in gneiss associated with *quartz*, *feldspar* and *actinolite*. Other ore near by has associated *ilmenite* and *zircon*.[6] Magnetic iron is found in many places in Cornwall of good quality but not much explored, as, near the foot of Butter Hill on Clarke's land and on Deer Hill on Wood's and Titus' lands.[7]

[1] Mather's R. p. 567. [2] Mather's R. p. 567. [3] Beck's R. p. 10.

[4] It must be one of the oldest in the State for it supplied a furnace in 1756 (twenty-one years previously to 1777 when it was abandoned), since when its ore has been carried to Queensborough, etc.—Beck's *Rep.* p. 10.

[5] Mather's R. p. 566. [6] Beck's R. p. 10. [7] Mather, p. 571.

The **Greenwood mine,** in Monroe township Orange county, two miles southeast of Greenwood furnace, shows three beds, side by side, the middle one 9 feet thick, dipping southeast in gneiss rocks; the ore mostly compact, hard, containing enough sulphur to require roasting. Hornblende augite, coccolite and mica crystals are large and numerous.[8]

The **Townsend Long mine,** five miles southwest of Southfield furnace, in Orange county, was systematically wrought long before the Revolution, being discovered by David Jones in 1761. It lies conformably in gneiss, is traceable over a mile, and was wrought for 40 rods in 1839, 16 feet wide with a few inches of rock-parting in the middle,[9] and crossed at right angles by a flint dyke 2 feet thick. The ore is bluish black strongly magnetic, but not polar, associated with hornblende, sahlite, slaty gneiss, gneissoid hornblende, and reddish granite. Dr. Beck says it was mined badly, closed up and reopened just previous to 1842. The gangue varies much, sometimes quartz, sometimes feldspar prevailing, and sometimes black mica. The ore will strike fire owing to disseminated minute crystals of quartz; course nearly north; dip east; fracture columnar, granular; hard to crush. Its spec. grav. is 4.885, analysis perox. 70.50, protox. 25.40, ox. mang. 1.60, silica etc. 2.50. Nearly 40,000 tons had been mined previous to 1842.[1]

The **Patterson mine** half a mile southwest of the last, is a bed of ore similar to the Long mine ore, 20 feet thick as mined 150 feet in length, sinking with the dip between granite rocks which are disturbed. It was discovered in 1831 by John Patterson and has yielded 1,000 tons per annum, of rich magnetic, polar ore, used to smelt with O'Neil and other infusible ores, or lean limonite ores.[2] It differs from the Long mine ore chiefly in containing more silica; and makes red-short iron.[3]

The **Mountain, Antoine, Conklin and New mines** lie nearly parallel in a group fifty rods north from the Patterson, each from 4 to 8 feet thick and yield alike a rich black magnetic polarized red-short ore, associated with very beautiful laminated

[8] Mather, p. 566. Beck, 7.

[9] Dr. Horton, Third Geol. Report, New York, 1839, pp. 163, 173. Mather says that but one layer 6 feet thick has been worked.—*Report*, 567.

[1] Dr. Beck. [2] Mather, p. 568. [3] Beck, p. 6.

sahlite, hornblende and feldspar. The Mountain was discovered in 1758 by a hunter, and chiefly worked before the Revolution, the iron being sent most of it to England, celebrated for its strength and fine polish.[4] Two fifteen inch dykes cross the vein at an angle of 45°.

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The **Crossway mine** a third of a mile further southwest than the Mountain was 65 feet deep and 150 yards long in 1842 in a vertical bed 14 feet thick of moderately red-short ore very similar to the Patterson, associated with hornblende epidote, mica and adularia. It was discovered by John Ball in 1793 and thirty thousand tons were taken out before 1842.[5]

The **Antoine** is a continuation of the Crossway, Mountain, Patterson vein thrown by a succession of faults. "The same rocks and minerals and intervening sheets of rock in the ore were observed." How could Prof. Mather write this sentence and imagine an igneous origin of the vein a possibility? How can the liveliest superstition accept as a fact an outflow of molten iron-ore along a crevasse several miles in length divided by a partition of rock like that which so naturally subdivides a coal bed or bed of shale?

The **Sterling mines** also in Monroe are about a mile southwest from Crossway mine at the south end of Sterling Pond at the north end of Sterling mountain, and opened for three miles along the outcrop of the vein of rich, granular, compact, cold-short ore associated with crystallized green hornblende, sahlite, green mica, fleshy feldspar and octahedral iron, between granite and coarse sienite greatly disturbed, but dipping northeast and east conformably, alternating with the ore a number of times not determined.[6] The ore lies naked about fifty rods wide by 150 yards in length; in many places its surface is even and polished as if ground off by the sliding of the rocks.[7] Prof. Mather says drift-scratches traverse it, he thinks from north to south. A sketch of the mines and lake is given from memory in plate 30 fig. 4 of Mather's Report. The first mine was discovered in 1750 and named after the proprietor Lord Stirling, and a blast-furnace erected in 1751 by Ward and Colton, since when up to 1842 about 140,000 tons had been taken out. It then averaged 2,000 tons per annum. The ore is neutral, fusible, strong, and

[4] Mather, Report, p. 568.
[5] Mather, Report, p. 569.
[6] This again shows the sedimentary structure.
[7] Dr. Horton.

largely used for ordnance casting and bar iron. No dykes are seen. The ore as seen is from 10 to 20 feet thick, inclining 30°, on a smooth grey granite rock, 3 feet thick, under which is a bed of soft pure rich ore, and under this again Dr. Horton pronounces positively to exist a third "immense bed." The ore is exposed on the mountain slope facing the lake, 801 yards along and 150 yards up and down, with 500,000 tons in sight in 1842. Some of the ore is pyritous.[8] It is evident from this description and from the sketch, that we have here a double or triple sediment curving around the ends of shallow anticlinal issuing from the end of the Stirling mountain.

The **Belcher mine** on the same property, but a mile and a half distant to the southwest at the southern end of the ridge, is a cold-short ore, believed to be a prolongation of the Sterling bed. It was found in 1792 by Jacob Belcher and was in 1839 wrought out 115 feet wide without touching walls [probably on a flat bed].[9] It yields 48 per cent iron.

The **Red mine** or **Spruce Swamp mine** is nearly three miles south of the Long mine (above described), was discovered in 1780 by J. Stuperfell and has been but little wrought because its ore is very pyritous and valuable only for fluxing hard refractory cold-short black oxides. These magnetic ore-beds alternate with rock layers and decompose rapidly to an iron rust powder.

The **Clove mine,** owned in 1842 by G. Wilkes, one mile south of Monroe village Orange county New York is the nearest to the New Jersey State line of the magnetic ore beds of the Highlands. It has been long and extensively mined; a compact, granular red-short ore, with more or less pyrites disseminated, and decomposed to a black powder at the south end which needs no roasting. The solid ore lies in beds from a few inches to a few feet in thickness alternating with rock layers and covering a great extent of ground with a very gentle dip. The openings were 500 feet long in 1839. The ore contains 98.80 proto-peroxide + 1.10 silica and alumina, and is associated with mica, hornblende, quartz, feldspar, asbestus, occasionally carbonate of lime, serpentine, octahedral chrome and soapstone. Granitoid gneiss is seen just on the eastern side of the ore bed,

[8] Mather, p. 570.

[9] Dr. Horton's Third Report.

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"which is stratified vertically and composed of magnetic oxide more or less mixed with pyrites and hornblende." The ore-parting rocks are sometimes gneiss loaded with magnetic ore-grains. Dr. Beck saw well characterized hematite on the surface in the immediate vicinity of the magnetic ore. Prof. Mather only saw it at a little distance to the north, under beds of gravel. Granite, gneiss and syenite occur to the west and southwest, and between them and the ore bed and a little west of the limonite (hematite) are seen beds of the calciferous (Lower Silurian No. II) limestone of the Champlain division "not more altered than the limestone near the Copake [hematite] ore bed [east of Hudson] or that on the eastern side of the Amenia [hematite] ore bed [east of Poughkeepsie]."[1] Here then we have all the phenomena of the Essex county beds of the Adirondack and Lake Champlain county reappearing with the reappearance of the including rocks, gneiss, serpentine and limestone of a well marked age, with the beds of hematite ores east of the Hudson to mediate between these distant localities. It is impossible to doubt the sedimentary nature of the deposits.

The **O'Neil or Nail mine** one mile southeast of the Clove is a vast bed of magnetic ore, owned in 1842 by Gouv. Kemble, and at that time opened 150 by 500 feet on the surface 20 feet deep, having been wrought since 1823 at the rate of 2,000 tons per annum, a portion of the southeast wall being visible, with a vertical dyke several feet thick cutting through the bed nearly east and west. The ore is often beautifully crystallized in octahedrons and rarely in cubes in the seams; contains pyrites, requires roasting; is hard and compact; analyzes 95.75 protoperoxide, 4.25, silica and alumina, and makes red-short iron; associated minerals, white and abundant calc-spar, rose garnet, green coccolite, dark sahlite, massive hornblende, flosferri arragonite, amianthus and serpentine.[2]

"A mass of syenite or feldspar rock projects into the mine on the southwest but it is more than half surrounded by ore which lies partly on opposite sides of it. The ore lies very irregularly, in some places very pure, in others more or less mixed with hornblende, serpentine, calc and rhomb spar, verd antique, etc. *Much of the ore seems to be an intimate union of magnetic oxide and serpentine*, so that it has much the aspect and color of the dark green serpentine; much seems also intimately blended with greenish hornblende. The mine is a place of great interest to the

[1] Mather, p. 572, from Horton, 1839, p. 162. [2] Horton in Mather.

mineralogist. Many very well characterized and beautiful minerals occur here. The crystallized magnetic ore makes the most brilliant and beautiful specimens of any locality I have ever seen vying with the richest from Elba." Prof. Mather then gives a list of minerals.

The **Torshee mine** half a mile southwest of the O'Neil is a mass of many alternating layers of magnetic ore and gneiss rock dipping 40° east, underlaid with gneiss, hornblende and augite and forming nearly the whole of a hill a quarter of a mile long and wide. Some of the ore is compact, some granular and loose like shot, with large bodies in the condition of a black powder free from pyrites, which to some extent contaminates the solid ore. Umber is abundant. Red garnet, brown tremolite, green coccolite, yellow and black serpentine, calc spar, asbestus and mica are present. The locality which furnishes large sheets of mica is half a mile further west. Garnets and augite abound in the rocks west of the mine.[3] The ore is sometimes cavernous or cellular where the umber lies and then consists of 52.75 peroxide, 44.10 protoxide, 3.15 silica and alumina, with traces of oxide titanium and manganese. The umber consists of 68.00 peroxide iron, 8.50 peroxide manganese, 6.50 silica and alumina, 17.00 water. This cavernous ore is especially esteemed by the furnace men; it need not be roasted.[4]

In southern New York in 1856 Suffern's and Ramapo forges work up pig-metal and scrap iron. Ramapo however has two bloomary fires for ore besides its steel works. Two abandoned forges once used the ore on the creek back of Warren, on the west bank of Tappan sea; and two old bloomaries on the Ramapo once worked up the ore; three more used to bloom Stirling ore. Now all this work is done by the furnaces at Greenwood Orange county, one anthracite (A 17) and one charcoal (E 37), using the magnetic ore from the Monroe mines within four miles east and west of the stack; the Southfield furnace (E 38) using California and Oregon and a little Crossway ores (all Sterling mines six miles southeast of the furnace); and the new Sterling furnace (E 39) using Lower California, Upper California, and Summit mine ores (1¾, 2 and 2¼ miles north), Great Sterling (2¾), Fourteen foot vein and Oregon eight foot vein (4), Crossway (4¼), Mountain vein (4½), Long Mine (4¾), and six or seven other small veins near the furnaces. The old Sterling furnace has been abandoned fifty years, so have the Croton, Haverstraw, Orange and Woodbury furnaces.[5]

[3] Horton in Mather. [4] Beck, p. 8. [5] Bulletin Amer. Iron Ass. July 1, 1857.

The belt of gneissoid Huronian rocks where it crosses **from New York into New Jersey** is about twenty miles wide, and where it crosses the Delaware river it is about twelve miles wide. It is crowded with iron works near the New York line. Its ores are similar to those of Essex and Clinton counties in northern New York, and cannot lie very far beneath the horizon of the Potsdam sandstone and Trenton limestone, which border it on the north and fill hollows between its ridges; just as they border the same rocks and ores upon Lake Champlain. In both regions graphite, pyroxene, tourmaline, garnet, scapolite, feldspar and other rarer minerals are abundant with many varieties. Magnetic iron occurs diffused in the rock as well as in beds, or groups of parallel beds lying in close proximity, separated by "barren country." The magnetic oxide prevails. The specular peroxide is abundant only at one locality and there it is mixed with the magnetic oxide. The beds are included between gneiss strata; their course is that of the mountain belt, north-northeast south-southwest and their dip commonly to the east-southeast at from 45° to 90°. Their thickness varies from a thread to twenty feet, including ore and gangue, from wall to wall. Occasionally horses of barren-ground slice up the ore, and sometimes cut across the bed, even displacing it. The ore itself is granular and crystalline, but not so coarse as the coarse ores of Lake Champlain; sometimes it is close, compact, smooth and lustrous; sometimes columnar or in square-jointed blocks; sometimes in magnetic grains mixed more or less with hornblende, actinolite, quartz, mica, calc spar and other crystals. Specimens from Dickerson's mine will sustain their own weight as magnets.

Supposing these beds to be original deposits, their nearly uniform dip to the southeast can only be explained by imagining the whole of this disturbed belt of Huronian rocks to lie in a series of anticlinal and synclinal waves, collapsed and leaning over on their northwest sides. Professor James T. Hodge, whose original manuscripts has been kindly furnished for these descriptions believes them to be veins ejected through parallel fissures conforming to the interstitial or bedding planes of the metamorphosed rocks in which they occur. On the other hand Dr. Kitchell of New Jersey in his third annual report of the geological survey for 1856 expresses the contrary and at present the more probable opinion that they are of sedimentary origin. He says:

In my last annual report, upwards of eighty iron mines were enumerated and described, all of which are situated in the counties of Sussex, Passaic, Morris, and Warren and within an area of three hundred and sixty square miles. Although some of them have been worked for a century and a half, and in early days furnished a very large proportion of the ore manufactured into iron in this country, yet they have been excavated to a very limited extent, many of them containing immense bodies of ore above water-level which may be economically extracted without the employment of expensive machinery. It is estimated that they could be made to yield, advantageously, no less than one million tons of ore annually for many years to come, which would be sufficient to supply half of the present annual consumption of iron in the United States.

The different forms in which magnetic iron ore occurs in this district, are as follows: First, **in granules disseminated** through the gneissoid rock as one of its necessary constituent minerals. The granules vary in size from particles so small that they cannot be seen with the naked eye, to grains corresponding in size with the other constituent minerals of the rock. Second, **in masses or bunches** of very limited extent. This form generally occurs in those rocks that are the most highly metamorphosed—as the quartzo-feldspathic and syenitic rocks. These rocks, when considered with respect to their constituent minerals, do not exhibit a distinct lamination, nor when considered *en masse* do they exhibit distinct lines of stratification, as in gneiss or in mica and hornblendic schists; nevertheless, they generally pass into these latter rocks so insensibly that no line of demarcation can be drawn between them. Third, **in seams or strata**, varying from the fraction of an inch to thirty feet in thickness. They alternate with strata of rock and coincide with them in strike and dip. The ore seams, as well as the rocky strata, pitch downward beneath the surface towards the northeast at variable angles, and on this account the ore is exposed on the surface but to a very limited extent.

The seams or deposits of ore are generally remarkably pure, but they frequently contain in admixture the constituent minerals of their accompanying rocks. Apatite (phosphate of lime), hornblende, quartz, feldspar and mica are most common. In some portions, as in the Dickerson and Byram ores, apatite, in the form of granules, uniformly disseminated through the ore seam, constitutes as much as ten per cent of it. This percentage may be considered as the maximum, and confined to few mines, and even to very limited spaces in those mines. Hornblende frequently enters largely into its composition, as in the Sweede mine, and many others. Mica, feldspar and hornblende are very frequently found entering largely into the composition of the ore seam, sometimes in granules irregularly disseminated through it, as in the Hibernia mines, and sometimes in laminæ alternating with laminæ of ore, as in the Beachglenn mine. Iron pyrites (sulphuret of iron) is also a common constituent of many of the deposits, among which may be mentioned the Silver, Haggerty and Stanhope mines. Quartz in small proportion, in the form of granules, disseminated throughout the ore, is not uncommon. Generally, when the ore contains a considerable quantity of the above-mentioned minerals in admixture, it is laminated, the planes of the lamination depending on one or more of the minerals. When, however, it is entirely or nearly free from impurities, it possesses a columnar structure, the general direction of the planes of the joints being at right angles to the inclination or dip of the ore seam. Large wedge-shaped masses of rock, composed of quartz, hornblende, feldspar, mica and magnetite, called by miners "horses," frequently occur imbedded in the ore seams. Generally a line of demarcation can be drawn between the "horse rock" and ore, but so insensibly do they

sometimes pass into each other that it is difficult to tell where the one begins and the other ends. They vary in extent, from regular seams or strata of rock alternating with the ore, to small irregular wedge-shaped masses, the longer axis corresponding with the strike of the strata, and its lamination, which is generally perceptible, corresponding with the lamination of the adjoining rocks.

That the rocky formation of this district, including the gneiss, the hornblende and mica schists, the magnetic iron ore, and the quartzo-feldspathic rocks, are of metamorphic origin, there can be but little doubt; consequently, it is conceived that they were originally deposited by water in a horizontal position, that they are composed of materials derived from preëxisting rocks, and that they were subsequently disturbed in their position, and altered by metamorphic agencies, which have caused them to assume their present form and position. The origin, therefore, of these deposits of magnetic iron ore, is identical and cotemporaneous with the rocky strata in which they are inclosed.

To such an extent is magnetic iron ore disseminated through the rocky formation, that **deflection of the magnetic needle** is of frequent occurrence; so much so, that great difficulty is often experienced in surveying with this instrument. The amount of deflection and the distance at which it is produced, depend on the quantity of magnetic ore disseminated in the rock, and its position with respect to the surface; and as these are variable, no rule can be established by which the amount of deflection and the distance at which it is produced can be calculated. A very small mass of magnetic ore near the surface is frequently sufficient to reverse the needle, even when it is placed several feet above the ore, as in the case of a surveyor's compass when supported on the tripod; and on the other hand, a large body of ore a few feet beneath the surface would produce but a slight deflection. Seams of ore five feet in thickness have been observed to deflect the needle at a distance of thirty feet; the intensity of its influence increasing as the magnetic axis of the ore is approached. Some deposits of ore possess more than one magnetic axis. On placing the needle on the outcrop of such a deposit, so that the axis of the needle will correspond with the magnetic axis of the ore, and then gradually moving the needle in the direction of the ore seam, it will be reversed as many times as there are magnetic axes in the deposit. This is probably due to the difference in intensity of the magnetic properties of the ore in different parts of the same deposit. When a seam of ore is capped with rock even to the extent of a few feet, its influence on the magnetic needle when placed directly over it on the surface, is very variable; in some localities producing a great deflection, and in others but very little. So variable have been the results of the observations, with respect to this, that no rule can be established that would determine the greatest depth at which the needle would be affected, nor that would determine the quantity of ore from a given deflection of the needle at the surface. The smallest fragments of ore frequently possess magnetic polarity and a magnetic axis; the extent of their magnetic qualities depending on their position with respect to the surface; the nearer to the surface, the greater will be their magnetic properties. This appears to depend on the action of surface water and atmospheric agents; for it has been frequently observed that ore when first taken out of a mine at a considerable depth, possessed but slight magnetic properties, but on being exposed to the atmosphere for a few months or years, it would increase so much that excellent hand specimens of loadstone for experimental purposes could be selected therefrom. Seams of ore that contain numerous joints and fissures, through which water and atmospheric

agents pass, possess more decided magnetic properties than those which are more compact and less free from crevices and fissures.[4]

"Sabine's observations of the inclination and intensity, at different parts of Scotland, do not at all indicate disturbances effected by large mountains at considerable distances." (Reich.) On the other hand, Hansteen "states that large mountain ranges exercise a sensible influence upon the mean direction of the magnetic needle. This result is obtained from an extended series of observations, made by himself, as to the deviation and dip of the magnetic needle, and the magnetic force, during a journey through Sweden, and especially through the mountainous western part of Norway."[5] Bischof, after citing numerous observations that have been made in various parts of the world by different observers, in regard to the influence of mountains on the magnetic needle, concludes as follows: "Assuming that it is magnetic iron ore alone, either as masses or disseminated through rocks, to which the magnetic influences are to be ascribed, and in my opinion this is quite unquestionable, it would seem, that magnetic observations, instituted with the same degree of care as those made by Reich, would be well adapted for the discovery of hidden beds of magnetic iron ore. Such observations might, therefore, prove eminently serviceable to the iron industry. Certainly, it would be requisite first to ascertain whether mountain masses, containing only disseminated magnetic iron ore, but extending over a considerable surface, would not produce as great an effect as beds of magnetic iron ore. Sabine's observations do not appear to favor this. But, however this may be, the magnetic needle indicates the presence of magnetic iron ore, where it cannot be recognized mineralogically, and demonstrates the very general distribution of this mineral." The greater number of the seams of ore in which the mines are situated have been discovered by indications of the magnetic needle. The use of the magnetic needle in revealing hidden beds of ore, of sufficient extent to be of economic value, requires considerable experience; even then the indications of the needle are very deceptive.

The bar iron made directly from these ores has always been considered of excellent quality, probably because the bloomaries, consuming little, selected carefully their stock. The old Franklin iron was famous for its broad white radiating crystalline structure, and exceeding toughness. But the pig iron made from these ores is apt to be either cold-short or red-shot, and needs mixed ores and subsequent refining. There has sprung up on the Lehigh a large demand for these ores to mix with the brown hematites of the Limestone Valley.

The Sterling beds mined in New York pass over into New Jersey and have been worked under many names. Nothing

[4] This looks as if peroxidation were the magnetizing agency, and that specular iron ore found as in Vermont under the pseudomorphous form of magnetic iron ore had lost its magnetism by being *over* peroxidized; in other words, by the proper magnetic proportion of the protoxide and peroxide being overturned by the peroxidation going too far.

[5] Chemical and Physical Geology of Gustav Bischof, translated by Benjamin H. Paul, ii. 500.

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but the broken nature of the country, and the distance from the anthracite coal region delays a new and larger exploitation of this valuable region. For a century the softened outcrop edges of the beds have been worked in surface quarries. The harder body of the bed below the weathering influence is left for a future necessity.

Professor H. D. Rogers in the Report of the Geological Survey of the State of New Jersey in 1840, describes three parallel zones of the Dover, Rockaway and Succasunny beds, consisting of strings of separate veins very nearly in a line. Their workings extend from a little northeast of Hibernia to a little southwest of Succasunny. But this classification is open to exceptions. The old Chester mine reopened, extends one of these three lines much further southwest; while the old Andover mine, not noticed by him, and the Glendon mine lately discovered a little southwest of it, in the range of the Scott's mountain ore, ought to add a fourth zone, unsurpassed by either of the others for the richness and abundance of its ores. The ores of Walkill mountain, Stanhope and Flanders may be connected. The southeast belt of Mr. Rogers contains Muir's mine and the Swede mine; the middle belt contains Hibernia, Jackson's or the Sussex Company's, and Dickerson's mines near Succasunny; the third belt contains the Denmark, Mount Hope, Blue, Teabo, Mount Pleasant, Harvey's Stirling and Burwell mines.

The hydrated peroxide ore is found in great quantities in Sussex county near Hamburg; but the whole aspect of this country of magnetic ores locked up in gneissoid mountains, is such a contrast with the country of hematite ores in limestone and sandstone lands beyond the Hudson that no one can hesitate to recognize some profound structural difference between the two regions. The Green mountains, in the prolongation northward of this region, are considered metamorphic palæozoic rocks by the Canadian geologists, and the mining of the magnetic ores certainly stops at the Hudson, all the mines to the north of that river being in brown hematite deposits in the Lower Silurian limestones. We must suppose therefore that the Huronian rocks with their iron ores really sink in the region of the Hudson and appear to the northward only in the Adirondac region west of lake Champlain. Coming southward therefore across

the Hudson we do not wonder at the breadth of these hitherto concealed and now emerging Huronian rocks, nor at the number and parallelism of their belts of magnetic ore.

Hamburg furnace gets its magnetic ore from **Sparta,** twelve miles off; and this same ore is carted 19 miles to Chester railroad station and sold in New York city, at an expense of $4 00.

Franklin furnace uses the Walkill mountain magnetic ore, four miles east. Professor Nutall thus described this famous ore in Silliman's Journal for 1822. The eastern bed is a black mountain mass, thirty or forty feet in width, of a scarcely at all magnetic ore containing 66 per cent. of peroxide of iron (equal to 46 per cent of iron,) 16 per cent of zinc and 17 per cent of the red oxide of manganese. Upon this rich ore the great furnace was built, but the ore has baffled the skill of all who have undertaken to smelt it, unless the patent process of Mr. Kent of the Cooper Furnaces at Trenton shall prove successful upon an extended trial. The ore, if used as a mixture with other magnetic ores, in a proportion exceeding one-tenth of the whole mixture, was found to produce a salamander of iron and manganese crystallizing under the blast into a solid mass.

Berthier[6] describes this ore as an amorphous mass showing some crystalline faces apparently belonging to the regular octahedron; black; of metallic lustre; deep red-brown powder; conchoidal fracture, glistening; specific gravity 5.09; magnetic without polarity; readily soluble in hot muriatic acid, giving off chlorine and precipitating entire peroxide iron. The accompanying minerals are oxide zinc containing deutoxide manganese; quartz; white lamellar carb. lime; garnet; pyroxene.

Francis Alger also describes this interesting locality in Silliman's Journal.[7] The ridge containing the principal mineral wealth of Sussex county, which commences at Sparta and runs through Stirling to Franklin, consists chiefly of granular limestone. Utön or Arendale in Europe hardly afford the mineralogist a finer cabinet ground. The zinc ore beds extend about four miles from Franklin to Stirling and no further, nor do boulders of zinc ore occur further northeast, but are found to the southwest, and in Pennsylvania the zinc appears again in mass. The limestone rocks dip generally 70° or 80° southeast, like the

[6] Traité des Essais par la voie sèche, vol. ii. 235.

[7] Vol. xlviii.

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gneissoid rocks hard by. Sometimes blended masses of gneiss and limestone appear including large and shapeless deposits of magnetic ore. Penetrating the limestone on the east side of Stirling hill we reach first three to seven feet of red oxide zinc and franklinite in about equal parts. Backing this and never intermixed with it stands a six inch plate of brown ferruginous heavy coarse crystalline limestone weathering easily. Then ten to twenty feet of regular pure franklinite ore, sometimes crystallized in the cavities or against the back face of the dark limestone. Behind this bed of ore are limestone strata until we reach the gneiss in the body of the hill.

Thus it appears that the Franklinite ore bed is not a vein, but an original deposit; a double bed of iron ore, like any in the coal-measures; inclosed in (Lower Silurian?) limestone, and subdivided by a thin deposit of limestone.

At Stirling the upper member of the bed, the red oxide of zinc forms a prominent wall along the side of the ridge, while the lower member of pure franklinite has had its outcrop degraded by the weather to a barren gravel. Fifty rods west of the principal opening, stands a vast isolated mass, unaccompanied by red oxide of zinc, and bearing no resemblance to either a bed or vein. The gneiss is close by, as it always is to the limestone wherever the magnetic ores exist.

As an ore of zinc, the pure foliated ore being in small quantity and the red oxide of zinc being estimated at one-half, this bed is valuable. The franklinite being removed by magnets from the roasted and crushed stock, the zinc is reduced in cast iron pots covered with charcoal dust. Dr. A. A. Hayes in Mr. Alger's report considers the manganese as a protoxide, and not as a deutoxide according to Berthier, and gives the composition: foliated red oxide of zinc 93.482, protoxide of manganese 5.5, peroxide of iron .360, scales of specular iron ore .440.

The important hold which this ore has had on public curiosity for many years warrants the introduction here of the following extract from Dr. Kitchell's Report.

Since Mr. Post's experiment, two furnaces have been erected for the reduction of this ore, one at Newark, at the zinc works of the New Jersey Zinc Company, and the other at Franklin, in the vicinity of the deposit of ore. The former was erected for the purpose of reducing the residuum (chiefly franklinite) of the zinc furnaces; the latter, for reducing the ore as it occurs in its native bed at Franklin, Sussex county.

The Newark Furnace was erected under the superintendence of Mr. C. E. Detmold (late President of the New Jersey Zinc Company), during the autumn of 1855. It is a small anthracite blast furnace, twenty feet high, eight feet bosh, and four and a half feet tunnel head; has three tuyères, and is arranged with hot blast. It is made of fire-brick, inclosed by a sheet iron mantle and strengthened by wrought iron bands; surmounted by a chimney, ten feet high and four feet six inches square, with three doors for charging the furnace. Near the top of the chimney is an opening four feet in diameter, through which the zinc passes into a sheet-iron pipe leading to the fan. The mouth of the chimney is closed by four dampers, which may be raised whenever the zinc and gases do not pass freely into the pipe.

The ore from which the residuum is derived, is a mixture of franklinite and red oxide of zinc. The zinc is extracted in the form of the white oxide by a process of sublimation; the ore having been crushed and mixed with a portion of fine coal as a reducing or deoxidizing agent, and then subjected to a high temperature in closely muffled furnaces, which causes the vapor of zinc to be evolved and consequently reoxydized, in which state it is used as a paint.

"The residuum obtained by this process is composed chiefly of franklinite and carbon, in the form of a fine powder, resembling fine sand. The fuel employed is anthracite, and the flux oyster-shells. The following quantities were consumed in producing a ton of pig iron: residuum, 2.90 tons; coal for furnace, 2.10 tons; coal for boilers, 1.10 tons; coal for hot blast, 0.16 tons=3.36 tons; oyster shells, 0.43 tons. For every ton of pig iron produced, one hundred and thirty-six pounds of the oxide of zinc were collected; and as the arrangement for allowing the escape of the zinc and gas was not sufficient to carry them off, it was found necessary to keep open one or two of the dampers at the mouth of the chimney, through which a large proportion of the zinc escaped and was lost. When the furnace was in good order, the production of pig iron was from thirty to forty tons per week; the residuum yielding from thirty-three to thirty-seven per cent of iron, and the coal consumed *in the furnace* from one and a half to two tons per ton of iron. After the furnace had been in blast twenty-one weeks, one of the boilers failed, which rendered it necessary to "blow out" the furnace. During the twenty-one weeks it was in blast, it consumed: residuum, 1,631 tons; coal, 1,860 tons. Its production was: pig iron, 552½ tons; oxide of zinc, 77,255 lbs.

The Franklin furnace was erected and put in blast in the winter of 1854, and was in operation only a few weeks. The following is an account of the working of the furnace for two weeks, ending March 25, 1855. During a part of this time zinc oxide was not collected, on account of a deficiency of power to work the fan: ore used, 102.50 tons; coal, 137.00 tons; limestone, 25.20 tons; iron made, 22.90 tons; oxide of zinc made, 22,084 lbs. Dr. A. A. Hayes, of Boston, who analyzed a specimen of the iron produced, reports: "In general physical characters, the sample resembled 'white pig iron,' but a closer inspection shows a different molecular arrangement, by which the crystals are affected in form and distinctness by chemical dissection. The mass of iron exhibits *two* distinct crystalline aggregations; the broad folia of one of these being separated by thin lamina of a different color, hardness, and composition, in this respect resembling meteoric iron. The color of the specimens is nearly that of the finer samples of metallic antimony; the masses divide easily, but the angles and edges of the imperfect crystals are harder than the hardest cast-steel, and in the attempts to obtain a powder, they became imbedded in its surface; a mean specific gravity is at 60° F. 7.665. Electrically, it presents a positive part, closely invested by a relatively highly negative body.

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Chemically, its characters are of an imperfect steel; its carbon constituent is in the state of that which has been deposited from carbureted gases by a high temperature and has no properties in common with graphite. No trace of sulphur was found. A trace of phosphuret of calcium could be detected, but neither zinc, chromium, vanadium, nor copper could be found. This occurrence of ore in iron I have often noticed in samples which *do not* present graphite. There was no evidence of the existence of the metallic bases of the earths either. In the following statement the iron is presented as a simple alloy, consisting in one hundred parts, of pure iron, 93.364; pure manganese, 3.204; pure carbon, 2.250; slag, silica .640; ore and alumina .240; lime .170. The mechanical and chemical constitution of this iron point to great ease in working it into malleable iron. Both the manganese and carbon are readily oxidized by the puddling, while the pure iron will take the form of tough or malleable iron very readily. It is also the kind of metal required for manufacturing steel, by fusion with oxide of manganese, losing in the operation a portion of carbon and all its metallic manganese."

An assay of a bar of franklinite iron, manufactured at Stanhope, by Mr. Edwin Post, was made at the French National Establishment, for the manufacture of chains and anchors for the navy, by Mr. Theophile Bornet, chief of the works and author of the "Tables of the Strength of Metals."

"The bar, obtained by direct treatment of the ore in a catalan forge, is 25 millimetres by 24.5 millimetres square, and presents a section in square millimetres of .... 612.50 *m.*
Charge under which the bar began to stretch, ... 15,000 *k.*
Elastic force, per millimetre, ... 24.5 *k.*
Charge under which the bar broke, ... 25,000 *k.*
Absolute tenacity, per millimetre, ... 40.8 *k.*
Elongation at the moment of fracture, per millimetre, ... 5 *m.*
Aspect of the fracture—all nerve.

"*Observations.*—The tensions of the hydraulic press of the national forges, are given by means of an excellent apparatus, which indicates the results with the greatest precision. An immense number of experiments have been made with this press, not only upon all the irons of France, but upon the best irons of England, Sweden, Spain and Siberia; never, until the present essay, has any bar been tried the *absolute tenacity* of which surpassed 40. kilogrammes per millimetre. Signed, TH. BORNET, *Chef des Travaux aux Forges Nationales de la Chassande.* Guerigny, 12*th July*, 1850. P. S.—The franklinite iron tried at the forges, works and welds to perfection."

This ore has lately come into favor as an antidote to red-short constituents in other ores. Pompton (New Jersey) pig iron, a very red-short metal, mixed .85, with .15 franklinite, works up into horseshoe iron. In Scotland late experiments seem to indicate that it is equally efficient in the opposite direction; .20 raw franklinite ore mixed in the puddling furnace with .80 Scotch cold-short pig metal makes a metal of extraordinary toughness. The zinc and manganese or the zinc alone seems thus

to take up both sulphur and phosphorus and leave the iron neutral.[8]

The following communication was made to the American Association, Albany, by Mr. A. C. Farrington. During the summer of 1848, while engaged in exploring the metalliferous veins upon what is called Mine Hill, near the Franklin furnace, New Jersey, my attention was arrested by the difference in structural arrangement presented by the opposite sides of the large vein of franklinite, at different places along its extent While much the largest portion of the mass appeared to consist of imperfect octahedral crystals, compacted or cemented, other parts appeared like an aggregation of their laminæ, its crystals resembling tabular spar. This latter portion was highly magnetic, and, in pulverizing, I found the hammer would take up large quantities of it. Knowing that other parts of the vein did not exhibit this property, I pursued my investigation for the purpose of ascertaining how much of the ore presented *this magnetic property.* The result was that *it was found only where the tabular crystals* prevailed, and they *only where the vein was in contact with syenite*, and in tracing across the vein in a right line, magnetic action was *not* perceptible *for more than four feet.* I repeated my experiments, and found four feet three inches was the maximum distance that the ore was found magnetic. I broke off fragments in a line across the vein, at the distance of three inches from each other, and, after pulverizing, weighed one hundred grains from each parcel, and applied a common magnet to them. The magnet would take up all or nearly all of the powder from such parts as came from the side of the vein nearest the igneous rock, and gradually diminished as they receded from it. I failed in establishing any regular series or ratio for the diminution of magnetic action, but inferred from the results that the iron of the Franklinite, in the parts of the vein in contact with syenite, was a *protoxide*, while *the mass of the vein was a peroxide ;* and intermediate, for the distance examined, as before stated, there was a mechanical mixture of the two oxides. In presenting these facts, an important geological question arises: Is the metamorphism of this metallic vein attributable to the agency of the intrusive rocks in contact with it; and, if so, should we not infer that the igneous intrusive rock is more recent than the vein of franklinite.*

The **Swede** mine eight miles from Pompton furnace is an adit level into two beds of magnetic ore, sometimes separated by a gneiss or feldspathic wall from two to four feet thick. The upper bed is a rich close-grained ore from eight to twelve feet thick; the lower is as thick, but mixed with mica and hornblende. The bed runs north-northeast and dips 50° to 60° east-southeast; is shut up in granitoid rocks and has few horses. The ore makes an excellent iron, and yields to an analysis by Dr. Wolcott Gibbs, oxide of iron 70.85 (iron 49.60); silica 19.71; alumina 7.81; magnesia 1.70. Both beds come off clean from the walls. The ore is shipped upon the canal direct to Boonton at a gross cost of 30 cents.

American Mining Chronicle, Oct. 16, 1858.

* Annual of Scientific Discovery, p. 302. This is a fine example of the difficulties into which the plutonists fall at every new and striking discovery in a mining region.

New Jersey.

The forges of this neighborhood, some of them very old, make blooms and rough slabs in catalan fires, out of magnetic ores in the same range with the mine last described. The most northeasterly of this second zone of mines, is the **Hibernia**, on the top of a high hill, variable and averaging perhaps nine feet. The **Jackson** mine, half a mile west of Dover, owned by the Crane Iron Company of Pennsylvania, is about seven feet thick.

Dickenson's mine near Succasunny on the same range, a mile and a half from the canal, is described by H. D. Rogers in his report on the Geology of New Jersey. The bed dips 60° southeast, between quartz and feldspar gneiss in which is occasionally mixed a little mica and crystals of oxidulated or magnetic ore; is 30 feet thick just at the entrance but averages about 12 feet; and furnishes three varieties of ore, blue ore next the foot wall, reddish ore next to the hanging wall, and sparry ore in separated veins between the permanent bed and hanging wall. In the case of one such vein of sparry ore twenty-two inches thick, there are three inches of rock between it and the red ore. The ore is granular, approaching the octahedron, and sometimes compact, and makes fine iron. Mr. Rogers reports about 1,500 tons per annum mined during the five years previous to his visit. Mr. Hodge in 1849 reports 800 tons per month sent to a number of furnaces in Pennsylvania.

Byram's mine, a little off the line of the last to the southeast, has been extensively wrought, and its ore sent off in every direction. The bed is 8 to 12 feet thick.

On the next range to the northwest the mines have been in many cases abandoned, not from any lack of ore however. The **Mount Hope Blue** mine is on a large and important bed, the old workings of which are at least 100 feet in depth by several hundred on a level. The **Mount Hope** mine is on the same high hill, four miles from the canal. The **Teabo** mine adjoins it towards the canal and has for many years supplied the Rockaway works. Its ore is columnar, somewhat mixed with actinolite and quartz, but one of the heaviest and richest ores of the district, better adapted for the bloomary than the high-blast furnace, but mixing well with the brown hematites. The bed is more regular than usual, from 8 to 10 feet thick and stands nearly vertical. The **Mount Pleasant** mine on the

same line was wrought within half a mile of the canal 220 feet below the meadow level when Mr. Stanton took it. Prof. Rogers describes it as averaging 8 feet thick, varying rapidly between great extremes, the ore occurring in fact in pods, between a regular wall of hard light-colored feldspar upon the lower side, and a hanging wall of chlorite and mica slate. One of the southwest galleries was crossed by a quartz dyke 14 feet in thickness beyond which the vein was recovered upheaved many feet to the southeast and in great confusion. The ore is excellent; some granular and some compact and columnar. The **Irondale** mines belonging to the Sussex Iron Company seem to be in the same range, two miles west of Dover and half a mile southwest of the canal. The Stanhope furnaces are nine miles further west and used the ore. The largest of several parallel veins is about 20 feet thick; the dip about 45°; and the principal workings near the surface. The ore which has a cold-short tendency, like most of the ores above described, is sent as far as the Lehigh furnaces, and adits have been driven into the veins at water level to meet a growing demand.

The Oxford furnace ores are black magnetic from 45 to 60 per cent, and in the immediate vicinity of the furnace, which was built and blown in March 1743. The ores lie in granitoid gneiss, conformably, in two principal and very variable beds, separated here and there by parallel beds of rock, as in double and triple coal beds, so that the whole thickness of ore is not always taken out. Several faults also heave the beds sideways and cause fractures and squeezes, one of which makes almost a semicircle. The adjacent strata or rather certain beds are full of crystals of magnetic ore replacing or associated with their hornblende crystals. The ore itself is here as elsewhere both massive and fragmentary and the massive ore is always refractory but makes an excellent iron. The forge pig bears a high character. Another bed of ore was opened in 1847 quarter of a mile from the furnace, one lens-shaped mass of which was 16 feet thick;[1] this "blue magnetic vein" is now reported by Mr. Scranton 22 feet thick and making good bar iron; the Harrison vein being red-short and the black magnetic vein makes the best car-wheel iron. In 1858 another large bed was

[1] J. T. Hodge, 1849.

New Jersey.

opened, and the sales of ore to other works are over 1,000 tons a month.[2]

The Andover mine, in the same range with and twenty miles northeast of the Oxford, seven miles north from the canal at Waterloo (the old Andover forge village) and about a mile northeast of Andover village cuts through the southwest end of a long gneiss ridge (No. I) surrounded by limestone (No. II.) The ridge is cleft into several prongs and in the northwestern cleft the principal bed of ore is seen dipping 60° east-southeast between gneiss walls from 30 to 56 feet apart for a hundred yards along the open quarry and 20 feet deep at the upper end (in 1849).[3] The bed is traced by trial shafts across the hill northeast. At the southwest end it is very poor, being a mere bed of slate charged with iron ore. Elsewhere it is a mass of light reddish ore in which as in a paste are embedded octahedral crystals of magnetic oxide. The ore as it comes out, paste and all, analyzes peroxide iron 70.72 (iron 49.50), silicious matter insoluble after fusion with carbonate soda 28.51, alumina 1.14, carbonate lime 0.57, manganese a trace. The red paste might be taken for peroxide of iron, but it is generally of too light color, assuming when ground a pink tinge. Before the blowpipe on charcoal it is fusible with difficulty into a bead, which is magnetic. With soda it indicates manganese, but with borax the reaction of manganese seems to be overcome by that of iron, the glass being red then yellow while hot and colorless cold. When the powder is heated it becomes of a brown color, as does that of manganese spar. I could detect no zinc with the blow-pipe. I have some fine crystals of the mineral which appear, however, as if they might be pseudomorphs of the magnetic oxide of iron. Plates of specular iron ore are also imbedded in this paste, and the whole mass passes into the peroxide, which is found in compact layers in the vein as pure and compact as the peroxide of the Iron mountain of Missouri.*

In the midst of this great vein, somewhat southeast of the

[1] Bulletin A. I. A. p. 84, note 44.

* J. T. Hodge.

[2] In March 1847 this ore bed was examined by Dr. Palmer, R. C. Taylor and Ab. S. Hewitt and bought by Cooper, Hewitt & Co. It is now in 1858 more shaley than it was. The mass above water level is described as having been "all oxide of iron" (for 50 or 60 feet above water level), in which the zinc was scarcely noticed and the iron made was particularly pure. But in reaching the plane of underground drainage the heavy sulphurets come in, as in the Polk county mines in Tennessee and elsewhere.

middle of it, is a body of magnetic oxide of iron from 10 to 12 feet in thickness pursuing the same course. This is a very dense ore and of uniform character; its color is a bluish black, and dispersed through it are extremely small crystals of a yellowish brown color, which resemble yellow blende. But with the microscope they are found to be of a cinnamon yellow, and too bright and clear for this mineral. I was not able to procure enough of the substance to determine what it was. This ore effervesces in the acids; and its composition I found was as follows: Peroxide iron 76.99 (iron 53.89), silica 8.04, carbonate lime 8.14, carb magnesia 3.74, alumina 1.78, manganese a trace. I have a specimen from some part of the vein much resembling the great mass of the red ore in appearance, but in which the parts containing the magnetic crystals proves to be a red steatite, similar to that of the Indian pipestone, and with it are veins of greenish white steatite. From the peculiarities of these ores they are worthy of a most thorough examination.*

Other parallel veins occur in the adjoining "swales," but of inferior importance. At the northern extremity of this mine still another prong and cleft laps by it on the western side, and in this is a wide vein of inferior ore and garnet rock lying in gneiss and limestone filled with small grains of colophonite. In the garnet rock I discovered a trace of tin, but on analysis by Dr. Wolcott Gibbs it proved but a mere trace. Its composition is peroxide iron 30.92 (iron 21.64), silica 35.32, lime 30.21, alumina 2.81, oxide of tin 0.18. Probably no better combination could be found for a flux for the richer ores than this; but care would be required to select it free from the sulphuret of iron, which prevails in some parts of the vein. Seams of galena are met with here, which near the surface promised to be abundant; the quantity however diminishes in sinking on the vein. In small spots it was nearly a foot thick, the galena very pure and containing, I found, 4 lbs. troy of silver to the ton of galena. Fine crystals of garnet, troostite, augite, etc., are obtained at this vein. Altogether it is by far the most interesting and perhaps the most important vein of the mining region.*

It is said that during the last century this ore was worked for steel, for the manufacture of which it proved well adapted. The bar iron made from it too bore a high reputation for tough-

* J. T. Hodge.

New Jersey.

ness. An old blast furnace still stands in Andover where the ore was smelted and the puddling furnaces and forge are seen on the bank of the canal at Waterloo. The Andover Iron Company was formerly a large and enterprising body and carried on a very extensive business for the times. It was broken up at last, the members being dispersed in all parts of the world, and there remained none to claim the mine or pay the taxes. It was wholly neglected when in 1847 by the perseverance of Mr. Hewitt a title was obtained to it at an expense of $6,000. He reopened the mine and with Peter Cooper, Esq., of New York and his son Edward Cooper, built the large furnaces at Philipsburg to run with these ores. In the summer and fall of 1848 mining operations were extensively carried on, from 500 to 800 tons a month being sent down to the canal to be transported to the furnaces at Philipsburg.[3]

The ores consumed in these Philipsburg furnaces have been obtained chiefly from the Andover mine, nearly two hundred thousand tons having already been consumed. The ores of the Roseville, Dickerson, Allen, Hibernia, Irondale and Ringwood mines have also been used alone, as well as mixed with Andover ores. At first, under the impression that Andover ore would not work well alone, it was mixed with hematite ore, in different proportions; but it was soon ascertained that the Andover ore worked better and made a superior iron to the mixture, and the hematite was consequently abandoned.[4] The charge is stated by Professor Kitchell to be as follows: Andover ores (specular), 2.25 tons, coal 1.75 tons, limestone 0.25 ton. The iron is similar to that produced from the franklinite ore, being highly crystalline, and in its fracture having a bright metallic lustre, resembling that of antimony. A large proportion has a foliated structure, being crystallized in laminæ; another variety has a fibrous structure, the fibres radiating from the centre to the outside of the pig; and another variety has a granular structure, the grains being coarse and crystalline. It is considered, for many purposes, superior to iron manufactured from magnetic ores, or account of its crystalline structure, caused by the presence of manganese and a more intimate union of the carbon and iron.

[3] J. T. Hodge, MSS. 1849.

[4] Kitchell, p. 23.

The charge of Roseville mine magnetic ore is 3 tons, coal 2.5, limestone 0.3. The small proportion of limestone required is owing to the presence of carbonate of lime mixed with the ore. The iron is red-short, but it is soft and very fine grained, and is well adapted to foundry purposes.

The charge of Ringwood mine magnetic ore (assorted) is 1.75 tons, coal 1.75, limestone 0.65.

The charge of Dickerson mine magnetic ore is 2 tons, coal 2, limestone 0.8. The iron is cold-short, even when mixed with one-fourth Andover ore, but makes a good foundry iron.

The charge of Allen mine magnetic ore is 2.25 tons, coal 2, limestone 0.5. The iron is slightly inclined to red-short, but makes a good forge iron, and when mixed with one-fourth Andover ore, produces a superior article, equal to the Andover.

The charge of Hibernia mine magnetic ore is 2 tons, coal 2, limestone 0.4. Iron similar to that produced from the Allen ore.[5]

The great Andover vein has not been found on the lands of the Crane Company northeast of the Cooper and Hewitt property, but the garnet vein has been found, but in too lean a form to work.[6]

The Glendon mine about three miles southwest of the Andover mine occurs near the junction of the gneiss (sandstone No. I) and limestone (No. II). It shows a very open ore in a bed 8 feet thick, falling to 4 feet in the shafting, and much debased with carbonate of lime. Gypsum also accompanies it.[7]

Other smaller ore beds are known in the Scots mountain and marble mountain range, and many small leaders have been found on hills near Waterloo.[8]

It is impossible not to recognize in the above descriptions the features of sedimentary local deposits of peroxide of iron at the base of the palæozoic or Lower Silurian limestones and in or on the previously deposited sands and slates; which at that time were horizontal and perhaps near the surface of the air; perhaps in

[5] "In the use of the above ores, the following results have been obtained: 1. Ores containing apatite (phosphate of lime), produce a cold-short iron. 2. Ores containing iron pyrites (sulphuret of iron), produce a red-short iron, but suitable for foundry purposes. 3. Ores containing manganese p:oduce a hard crystalline iron, which is neither cold nor red-short, but of great tenacity. 4. Ores 1 and 2, or 1 and 3, or 2 and 3, mixed in suitable proportions, produce a neutral iron, suitable for forge purposes.'

[6] [7] [8] J. T. Hodge.

the air; previous to the deeper submergence during which the limestones were deposited.

New Jersey.

Just north of Philipsburg, New Jersey (writes Prof. Hodge), there is a very curious locality of specular ore, unreliable in quantity but of great purity and its mode of occurrence novel. It is in place on the steep crest of Marble mountain in what I can call nothing else than *blotches* incrusting the massive steatitic slates and occasionally in *strata* running a few feet into the slates and disappearing. In the drift are great quantities of the ore; hundreds of dollars' worth might be profitably gathered up; they are also spread over the fields to the south as far as the Delaware; I saw twelve tons of boulders taken out of one hole. Could the ore be found in quantity, the purity and locality would give it great value.—*Jan.* 11, 1857.

The most thorough discussion of an iron mine region in America is that by Prof. Kitchell of the mining district of northern New Jersey in his Second Annual Geological Report from page 146 to page 230 illustrated with maps and sections, mine machinery and lists of minerals found among the ores. He describes in succession, beginning with the northwesternmost belt of Pochunck, Pomple hill, Andover and Alamuche mountains, and Vernon and Wallkill valleys:—

Pochunck mine,	Franklin mine,	Tar mine,	Chapin mine,
Simpson "	Stirling "	Andover mine,	Brookfield mine,

Then the mines of the Wawayanda, Wallkill, Hopatcong, and Schooley's mountain range as follows:—

Wawayanda,	Sherman,	Noland,	Lawrence,
Green,	Ford & Scofield,	Roseville,	
Williams,	Weldon,	Silver,	
Edsall,	Duffee,	Haggarty,	
Ogden,	Hurdtown,	Stanhope,	
Vulcan.			

Then the Mount Olive mines, as follows:—

Osborn,	Drake,	Stevens,	Marsh.
Hilts.			

Then the Ringwood mines, as follows:—

Oak,	Caler,	Blue,	Hard,	Splitrock,
Peters,	New Wood,	Mule,	Cannon.	

Then the Mount Hope mines, as follows:—

Mount Hope Blue,	Allen,	Jackson,	Hibernia,
Teabo Vein,	Richard,	Randall Hill,	Lower Wood,
Brannin,	Mount Pleasant,	Mellen,	Glendon,
South Vein,	Huff & Burwell,	Byram,	Willis,
Mount Hope tunnel,	Harvey & North river,	Brotherton,	Beach,
Hickory Hill,	Corwin,	Dickerson,	Beachglen,
Elizabeth,	Sterling,	King,	Kitchell & Muir,
Teabo,	Hubbard,	Logan,	Swede.

In northern New Jersey in 1857 the following forge bloomaries used the following ores named after the mines or openings—sometimes many on one vein, as it passes across adjoining properties each of which has its mine. Ringwood (F 26)

and Long Pond (F 27), use Ringwood ore similar to the Arnold ore in northern New York, from a bed on which are *twenty-two* distinct openings. Bloomingdale (F 29) use Ringwood ore, 10 miles northwest. Smith's (F 30) uses Ringwood, Allan, Byram (one mile from Allan), Succasunna, separately or mixed.—Charlottenburg (F 31) uses Hibernia 8 miles SSW, Ogden 9 miles W, mixed. The ores in this neighborhood are so occupied now by the Pennsylvania iron-works that it is difficult for the neighboring forges to get them.—Turner's, Stockholm, Methodist and Herringbone (F 32, 33, 34, 35) all use Ringwood magnetic, 16 miles NE, Stockholm 2½ NE, Allan 16 miles south.—Windham (F 36) uses Ringwood ore with a separator.—Cantistear (F 61) uses Ringwood, Allan's, Mount Hope ores, mixing the two varieties of Ringwood —Decker's Sparta (F 62) uses Ogden (separated) 6 miles east.—Stony Brook (F 37) uses Mount Hope 15 miles SW, Hibernia sometimes, 8 miles west, or Ringwood 17 NE, simple or mixed.—Decker's Rockaway (F 38) uses some Hibernia, mostly Mount Hope, mixed.—Dixon's Rockaway (F 39) uses Allan and a little Hibernia.—Powerville (F 40) uses Hibernia, with a separator, 2¼ tons making 1 ton of iron.—Old Boonton (F 41) Durham (F 43) Rechter's Meriden (F 46) use chiefly Allan ore.—Troy (F 42) mixes Hibernia with Allan making one ton out of 2½.—Stickel's Meriden (F 45) mixes a little Beach ore 3½ SW, with Allan and rarely Hibernia 2½ W alone.—Beachglen (F 47) uses mostly Hibernia magnetic one mile north, or lately Beach ore ¾ west, with some Allan. They say here Hibernia is not improved by mixing.—Bloomary (F 49) uses sorted Allan 2½ tons to 1 of finished bar. It is a richer ore than Hibernia. Denmark (F 50) uses magnetic Mount Hope ore 2½ miles south.—Middle (F 51) uses Allan ore 3 miles SSE, Mount Hope 2 SE, mixed, some Mount Pleasant 3½ SSW. "There is a vein of hematite half a mile south."—Walley (F 53) uses Succasunna 4 miles south, half mile NE of General Dickerson's mine. Lower Longwood (F 54) uses Allan 6 miles SE, some Hopewell 9 miles NW depended in 1857 on Welden mine 3 miles NW.—Upper Longwood (F 55) uses Allan.—Hardbargain (F 56) uses Allan, some little Ogden, a little Mount Pleasant and Irondale.—Petersburg (F 57) uses Allan, sometimes Ringwood and Ogden.—Sweedeland (F 58) uses Allan, used in 1856 mostly Ogden, some Succasunna, formerly Mount Pleasant, mix when possible also uses Ford ore 2 miles southwest.—Russia (F 59) uses Oakhill magnetic 3 miles NNW, a new mine, 200 yards north of the Ogden, the ore of which is approved and will be used unmixed; formerly used Vulcan-head ore a quarter of a mile SW of Ogden.—Hopewell (F 60) used in 1856 Oakhill, formerly Ogden.—Eagle (F 63) uses magnetic ore from four openings close together a mile east.—Morris (F 65) uses Vulcan-head magnetic ore (separated in the works) 4 miles east, three openings.—Columbia (F 66) uses magnetic Dickerson ore, and ore from the Glendon Company's mines in Morris county (2½ ore to 1 iron). Roseville, Lockwood and New Andover (F 67, 68, 69) use Dickerson ore (50 per cent, Succasunna), 8 miles S.E. and 4 miles west of Dover. Shippenport (F 70) uses "blue ore" from Hibernia and Byrom mines and red ore from Waterloo. Has a separator cylinder with 500 magnets and makes a ton of iron from 2 tons cleaned ore from 2½ to 3 crude ore.—Bartleysville (F 72) uses Mount Pleasant ore, 3 tons to 1 iron.—Welsh's old Petersburg (F 73) uses Dickerson's ore 8 miles ENE, 2½ tons to 1 of rivet iron, 2¼ to 1 of boiler iron.—Budd's (F 74, 75) use their own ore close by.[1]

[1] B. S. Lyman and J. Lesley Jun., in Bulletin of Amer. Iron Assoc., pages 92, 93, July, 1857.

Pennsylvania.

Entering Pennsylvania the magnetic ores of the primary, azoic or huronian system dwindle to a shadow. The reputation of this State for iron has resulted more from the energetic, persevering German use, for a century of years, of what ores do exist, than from any extraordinary wealth of iron of which she can boast; certainly not from any actual preëminence of mineral wealth over her sister States. New York, New Jersey, Virginia and North Carolina are far more liberally endowed by nature in this respect than she. The immense magnetic deposits of New York and New Jersey almost disappear just after entering her limits. The brown hematite beds of her great valley will not seem extraordinary to one who has become familiar with those of New York, Massachusetts and Vermont, Virginia and Tennessee. Her fossil ore out-crop is not more extensive than lean and uncertain compared with that of the South. And the carbonate and hematized carbonate out-crops in and under her coal measures will hardly bear comparison with those of the grander outspread of the same formations in Ohio, Kentucky and western Virginia. But her people came from the land of the Stückofen, the fatherland of mineralogy and metallurgy; and came, a people of peaceful, thrifty and industrious habits, to settle midway between the rigors of the North and the enervation of the South, to illustrate a free soil with the dignities and successes of free labor.

The primary ore of New Jersey crosses the Delaware below Easton. At the old Lehigh-hill mine, now abandoned, two and a quarter miles south of Easton, the rock is a mixture of quartz and feldspar with occasionally a little epidote; on the southern side of the ridge are talc slates. The vein lies in contact with syenites consisting largely of green sahlite. The ore is very compact and dips northwest at the old abandoned mine.[1] Several small veins pass up the valley of Durham creek past the anthracite furnaces. The quantity is nevertheless considerable, but the mines remained for many years unwrought, owing to the neighborhood of the scattered brown hematite beds of the Lehigh valley. The entrance to the magnetic ore mine is within 300 yards of the two Durham anthracite stacks; the average width of the vein it works, 6 feet; strike northeast, dip

[1] Boyé in 5th Annual Report, p. 39.

southeast. The vein is traceable a mile and a half and is drifted in, at three points, for 800, 200 and 1300 feet. The old mine on the top of the hill south of Durham creek on the old Philadelphia road was abandoned when Prof. Boyé reported in 1841.[2] The belt of ore to which it belongs may be followed along the range of Durham hills and in the furnace valley for four miles. The furnaces use with this ore black hematite ore from a vein on the New Jersey shore opposite, and brown hematite from nests 500 yards, 2 miles and 3½ miles west of the stacks, others being known to exist all the way to Hellerstown, Trexlerville and Reading. The absence of any considerable body of magnetic ore in this region is however forcibly illustrated by the fact that the numerous great Lehigh anthracite furnaces have purchased mines in New Jersey, and bring their ores from that distance to mix with their brown hematites; while the furnaces of the Schuylkill and Susquehanna all get their magnetic ore to mix from one mine, the Cornwall south of Lebanon.

On the northernmost of the two primary hills, east of the Saucon, and about a mile northeast of Hellerstown, a vein of magnetic iron ore shows itself in several places, though the quantity of ore here is probably not great. It is much mixed with quartz, though we obtained some tolerably pure specimens. A syenitic dyke, composed chiefly of sahlite and hornblende accompanies the ore, and seems to have been the chief object of attention to those who have undertaken mining here. *Brown argillaceous iron ore* shows itself on the surface in some abundance, on the north side of this hill, near the junction of the primary rocks and the limestone. The appearances of ore are promising on Dillingham's farm, and much fibrous hematite is found on Hartman's, the next farm to the north. An open porous ore, in considerable quantity, is visible in a field on the latter place.

Fragments of magnetic iron ore occur in many places on the surface of the bold hill of primary rocks, south of the Lehigh, at Bethlehem, where some search has been made for it by digging. Southwest of Shimersville, near the east end of the same ridge, a vein of green sahlite, which has been mistaken for iron ore, shows itself near the summit of a hill. Close to this spot, some true iron ore has been found by us, the source of which is probably a little north of the sahlite. Epidote, mixed with iron ore, also occurs here. Further westward, near the summit of the same ridge, magnetic iron ore in a talcose rock is visible, near Shuber's, three miles from Bethlehem; it has not been dug for. The same variety of ore, of excellent quality, is found on the surface, near the top of the northern primary ridge south of Allentown, at a spot a little west of the Philadelphia road. A less magnetic variety is met with on the northern slope of the hill, a mile to the east of the road. Further to the southwest, the magnetic iron ore shows itself in the primary hill, three miles southeast from Metztown, the spot being a little west of the Philadel-

[2] Fifth Annual Report, p. 39.

Pennsylvania.

phia road. It is on the southern side of the second primary ridge from the north, on lands of Messrs. Trine and Peter Fegly, the line dividing their tracts passing through the mine. The ore occurs in three regular veins, dipping with the adjoining strata, at an angle of 50° to the south-southeast. The southern vein is about a foot and a half thick; north of it occurs a stratum of rock (gneiss), eight feet across, in contact with which is the middle vein, separated near its outcrop into two branches, which at a little depth unite into one vein; this is bounded on the north by a stratum of rock about four feet in thickness, and directly in contact with this, is the third or northern vein, having a thickness of two feet. The rock which incloses these several veins, is a coarse, regularly stratified gneiss, a mixture chiefly of quartz and feldspar.

Some miles to the south of the above, magnetic iron ore occurs on the border of Colebrookdale and Hereford townships, in the Mount Pleasant iron mines. In the northeastern excavation, belonging to Isaac Berthou, the ore occurs between syenitic rocks, and is itself a mixture of rotten syenite and magnetic oxide. It is worked open to the air, in a drift ten or twelve feet wide, ranging east of north. The dip here is 65° and a little south of east. This mine, in the course of seven weeks of active operations, has yielded seven hundred tons of rich ore. The quality of the ore is however variable. A few hundred yards more to the southwest, is the mine owned by John Landis; it includes two large excavations, one of them twenty feet wide and sixty or seventy feet long, and sixty feet deep, pursuing apparently a regular vein or bed parallel with the strata. The ore removed at various times amounts to about three thousand tons. The second excavation bears a little north of east from the above. Two other excavations, on property belonging to Peter Disher, occur about two hundred yards west of south from these. Here the bed has a nearly east and west direction, and may probably be the same which contains the mines just previously spoken of. This ore, more compact than that of the other mines, is stated to have made a rather red-short iron. The excavations are on a less scale than the largest one on Landis' place.

It would be important at the present day to ascertain, if possible, the causes which led to the abandonment of the magnetic iron ores of the region under review. The ore which supplied the old Durham furnace, in Bucks county, now long neglected, is said to have made an iron of excellent quality. Should it appear that a deficiency of good fuel, not the want of ore, was the difficulty, we may hope to see these localities once more resorted to, now that anthracite coal, so easily had in this neighborhood, proves itself so admirably adapted for smelting those harder ores which require a disproportioned expenditure of charcoal.

Brown or hematitic iron ore, in various forms, is often met with, in connection with the sandstone and limestone embraced in the chain of the South mountains. A usual place for the ore is near the junction of these formations with the underlying primary. Ore occurs in this position, near the border of the limestone, at the northern foot of the Lehigh hills, in many spots. Several excavations have been made about a mile in a direct line from South Easton, on the premises of John Bess. One of these was by a shaft about three hundred yards from his house. It is fifty-five feet deep, the first ten feet being through diluvium, the next ten feet through ore and ore ground, and the remainder of the distance through clay. Two other holes, each forty-two feet deep, were dug about three hundred yards from the above. In one of these, the covering of diluvium was fourteen feet thick, below which occurs the ore. The mining was done by the proprietors of the South Easton furnace, who paid an ore rent to the owner of thirty-seven and a half cents per ton.

The geological situation of this ore is probably upon the sandstone, F. I. An unsuccessful excavation was made near the top of the hill, where gneiss and syenite, and other primary rocks were struck. About three miles westward from South Easton, a mine has been opened, at Jacob Woodring's, in a hollow between two spurs of the primary chain. It was not wrought at the time of our examination. The shaft here is said to be ninety feet deep, passing through diluvium and clay for fifty-five feet, before any ore was found. The ore is moderately rich, but contains some manganese. The limestone shows itself on the surface, about three hundred yards north of the ore. Westward of these localities, surface signs of ore are abundant, as at Ihrie's and Brotzman's, half a mile south of the Lehigh. At Brotzman's, where some manganese is associated with the ore, the diggings were made probably too high in the side of the hill, being apparently outside of the edge of the limestone. The ore here is rough and sandy, and contains compact black oxide of manganese in some abundance. A little hill, further west, on the same form, lying within the limestone, shows a much better ore on the surface. On Richards's farm, in the same range as Brotzman's, but further west, surface ore is quite abundant, some of it being fibrous hematite. The next farm westward, presents the same indications. At the period of our exploration, the Lehigh Crane Iron Company, whose works are situated on the Lehigh, three miles above Allentown, were about to commence some shafts on Richards's farm. They have since, it is said, purchased Ihrie's, so that it is now probable that the ores of this neighborhood will be well investigated. Above Richards's, the primary formation approaches the river, cuts out the limestone, and consequently, the ore. But the limestone again showing itself higher up the river, a little ore has been dug above Bethlehem bridge, where, however, it is probably exhausted. Pursuing the same line to the southwest, we find an iron mine (Swartz's), at present neglected, about three-fourths of a mile southwest of Emaus. At this spot there is only one mine hole, about forty feet deep. Smelted alone, this ore made a cold-short iron, and was therefore usually mingled with other ores, principally with that from Breinig's mine. In some of the specimens found here, no manganese could be detected, though some of the ore has a manganesian aspect. Its geological position is in diluvium, lying near the border of the limestone.

The next locality of importance, is the old iron mine belonging to Oley furnace, nearly two miles northwest from Fredensburg. At this spot the ore was dug from immediately under an outcrop of the sandstone F. I, the digging running parallel with it for more than a hundred yards, and being eighteen or twenty feet deep, and eight or ten feet wide. This mine, now abandoned, furnished us some specimens from the side wall of the excavation; these are argillaceous and laminated, and of a purplish red color. A shaft unites the main excavation with another nearly under the first, having about the same direction, but descending more perpendicularly. This latter mine is from three to five feet wide; the wall is of primary rock, chiefly feldspathic and hornblendic gneiss, but sometimes entirely micaceous, and it contains, in certain places, magnetic and micaceous iron ore. The proprietors of Olney furnace propose reopening this old mine, having nearly completed a tunnel now six hundred feet long, intended to reach the lower excavation. The rocks passed through in the tunnel, are gneiss, syenite, hornblende, and micaceous slates.

On Pine creek, in Pike township, some diggings have been made for ore, about half a mile southeast from Lobach's mill. The ore has the aspect of a talcose slate, charged with the oxide of iron; it has a laminated or rather a fibrous structure. There is a rather large excavation at Boyerstown, belonging to Daniel Feglic. At

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the time it was visited, the opening was filled with water. The rock accompanying the ore is a light green soft variety of slate, dipping east. The ore itself is dull black, and contains many crystals of iron pyrites; it is said to have made a cold-short iron, and to contain copper, of which however, no trace was visible. A short distance west of south from the above, occurs another mine, belonging to John Rhodder, where the ore is more compact. Both these localities are connected probably with the middle secondary red sandstone formation.[3]

The following are Dr. Rogers's analyses of the magnetic ores of Trine & Fegly's mine, three miles southeast from Mitztown, Berks county, A, and from one mile southeast of Hellerstown, Lehigh county, B:—

	A.	B.
Magnetic oxide,	88.92	85.50
Silica,	10.60	12.60
Water,	0.20	1.25
Alumina,	a trace.	a trace.
Pure iron,	65.52	63.00

Hampton charcoal furnace (E 48) situated in the prolongation of the Durham hills 12 miles southwest of Allentown, mixes a black, somewhat magnetic, neutral oxide from Barto's banks in Washington township, 7 miles to the southwest of it, with the brown hematites around it to the north, and makes a first class car-wheel iron. Mary Ann furnace (E 49) 8 miles southwest of Trexlerstown, also mixes with its brown hematites one-fourth magnetic from some vein within a couple of miles. Oley furnace (E 50), 2 miles east of Pricetown, mixes magnetic ore from Zinnor's bank at Rothruckville, 12 miles distant. Mount Laurel furnace (once Alsace, E 52) gets a grey magnetic ore like the Cornwall from Wheatfield's banks 7 miles beyond the Schuylkill, west of Reading.

The ore at Daniel Fegle's Boyerstown bank Colebrookdale township Berks county Pennsylvania is described by Boyé as a very different looking ore from that of the Cornwall mine. Dr. R. E. Rogers describes the specimen he analyzed as dark dull grey approaching black, with glimmering crystalline points, powder black; slightly effervesces with acids, contains green chloritic clay, acts on the needle, lies in red shale near the contact with primary rocks of the South mountain; composition 86.67 magnetic oxide, 7.72 silica etc. 2.60 magnesia, 1.36 alumina, 0.80 carbonate lime = 62.22 pure iron. Boyé says that the Middle Red sandstone [New Red] covers the primaries from Rhoad's mill on Ironstone creek going eastward to Boyerstown, without the intervention of Sandstone I or Limestone II. The

[3] Boye's Report, 1841, as published by Rogers in the Fifth Annual Report, p. 40.

rock next the Fegle ore is a soft green slate dipping east from the ore, the excavation running north-northeast. The ore is dull black containing many crystals of iron pyrites ; in one piece of ore was found a piece of crystalline limestone. Green chlorite slate bounds the ore on the west also. The ore makes cold-short iron (like the Cornwall) ; no copper was seen. Sandstone dips 25° west of north in a very small hill west of north of the mine, and north of this hill rises a high hill covered with earth and pieces of granite and syenite. Rhodder's mine is just west of south of Fegle's and has a compacter ore *associated with red sandstone.* The hills to the north, northeast and northwest of Boyerstown are all primary (mostly white gneiss of soft decomposing feldspar and quartz, alternating with a syenitic rock of the same feldspar and crystals of hornblende) covered with fertile soil.[4]

The Warwick ore near Morgantown Berks county Pennsylvania was thus described in Dr. Rogers's analysis : black, metallic rather dull, rather cavernous, cell walls coated with ferruginous and talcose matter and perfect crystals of oxidulated iron in rhombic dodecahedrons, magnetic, polar, composition 97.61 magnetic oxide, 1.69 silica etc. a trace of alumina, no titanic acid, = 70.90 pure iron.

The Cornwall mine is an open quarry on the south side of a low hill at the north foot of which lie the Cornwall furnaces and from the top of which can be seen Lebanon six miles north, with its four anthracite stacks. The ore is nearly black, dull with brilliant points, somewhat cellular, the cells containing small octahedrals of ore and a whitish asbestiform mineral, magnetic, polar, analyzing : 98.00 magnetic oxide, 0.84 alumina, 0.24 silica, etc., making 70.34 pure iron, according to Dr. Rogers ;[5] but Prof. Boyé found in one specimen of the furnace slag from this ore 3.80 and in another 12.5 *magnesia*, showing that the original gangue must have been magnesian, unless we are to suppose the whole of such a percentage to come from a magnesian limestone flux. In this mine are found large specimens of rich copper ore, a metal seemingly widely distributed through the mass, as it is at the Warwick mine, and reported to be sometimes at Fegly's Boyerstown mine. This circumstance taken

[4] Extract in 1859 from MSS. Report of 1838.

[5] Fourth An Rep. p. 213.

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in connection with two others, viz. that the New Red Sandstone is the home of the copper ores of this region, and that other beds of iron ore (not magnetic indeed) occur at other points of the geographical limits of this formation, lend strong assurance to those who explain these great masses of ore as of middle secondary and not of primary age. But we must remember that copper and iron occur together in the subsilurian rocks of Canada, Tennessee and Virginia, of an older date than that of the Cornwall slates, and moreover at Cornwall the Lower Silurian Limestone has at length been found walling the ore, as it does in the New York beds of hematites. We need only consider the presence of the New Red and its Trap to have afforded the needful conditions for the change of a hematite bed of Potsdam age into magnetic ore. This may have been effected by the chemical character of the New Red waters.

The same grey magnetic ore of Cornwall appears west of the Susquehanna, according to specimens sent for analysis to Prof. Boyé. Georgianna furnace (E 64) used at one time magnetic ore from Dillsburg, York county, eight miles south-southeast of Mechanicsburg, but abandoned it for Cornwall ore. Chestnut Grove furnace (E 69) half way between Carlisle and Gettysburg, in the South mountains, has a magnetic ore mine one mile east and mixes with it one-fourth brown hematite. Carlisle furnace (E 70) five miles southeast of Carlisle at the north foot of the South mountain, pays a dollar a ton for magnetic ore from a vein opened six miles to the east-southeast of it. Cumberland furnace (E 74) at the north foot of the South mountain 11 miles from Shippensburg, uses the Dillstown black magnetic oxide although it comes from 13 miles due east of it.[6]

The **chromiferous** and **titaniferous** iron ores of the Pennsylvania-Maryland State line upon the Susquehanna river are described on page 171 of Rogers's Final Report, vol. i. in connection with the belt of Serpentine rocks in which they occur.* Two principal mines about 150 feet deep, a little west of the Horseshoe Ford of the East Branch of the Octorara, have yielded several thousand tons per annum and in fact furnish most of the chromate of iron exported or consumed at home.

[6] Bulletin A. I. A. 1858, pp. 84, 85.

* See page 413 above.

The chief vein strikes northeast and southwest dipping 45° northwest, and has been pursued 300 feet, irregularly opening to 20 feet and shutting down to nothing, and throwing off branches, some of which return. In four or five localities along this serpentine belt commencing near the Horseshoe and ending three miles from the Susquehanna, titaniferous iron ore is found, but very little mined; some hundred tons of birdseye iron ore have been taken out near the Baptist meeting-house.[7]

Mr. Rogers says that a careful examination of these two belts of serpentine cannot fail to convince any observant geologist that ordinary serpentine comprehends both a stratified and an unstratified rock. Pure serpentine is here found only in the form of dykes intruded through a stratified serpentinous talcose rock, evidently a metamorphic clay-slate—the mica and talc formation of the Susquehanna. The stratified serpentinous rock seems to have been impregnated with the magnesian minerals during the intrusion of these veins of igneous serpentine. This is no place for discussing the most difficult problems with which geology has amused herself in torturing the fancy and exercising the observing powers of her children; but it is always needful in a useful book to guard the uninitiated against the over-confident assertions of the more advanced. There is as yet no certainty that serpentine was ever an igneous injection. On the contrary the probabilities accumulate that every kind of serpentine is a sedimentary or chemical precipitate. Large beds of it lie between sands and clays which show no trace of fiery action. Hundreds of feet of sands and clays (metamorphosed it is true but how is the question) are described by Mr. Rogers and others as "serpentinous" or suffused with serpentine elements; how could this occur if serpentine dykes were the origin of these elements? The magnesia in the rocks and in the dykes must have a common origin it is true, but it is no less certain that the only conceivable common origin in such a case is water—aqueous deposition; the metamorphism of the rocks if not the genesis of the dykes must be regarded as aqueous—a slow maceration in the one case and infiltration in the other. If so the chromic and titaniferous iron are also aqueous sediments like the hematites, the carbonates, the lead and zinc of the west, and some at least of the gold and copper of the south; as pseudomorphic crystals and other aspects of these metals go to show. (See chapter on Brown Hematites).

The most interesting question raised by these deposits is one of geological chronology. The magnesian, serpentine and steatite and garnet rocks of Vermont and Canada holding chromic and titaniferous iron ores, are shown by the Canada survey to be of Palæozoic age, the age of the upper part of the Hudson river group, our No. III, and Rogers's Matinal Shales; whereas these Maryland State line serpentines, etc. are placed in the azoic system beneath the primal slates and Potsdam

[7] The mineral described by Dr. Genth, from Texas, Lancaster county, Pa. (Keller and Tied. Nordamer. Monatsb. iii. 487), as Nickel-Gymnite, but which Prof. Dana (System Mineralogy, p. 285) considers a variety of Hydrophite, I have found near Webster, Jackson county, N. C., in a band of serpentine, associated with chrome iron; (this band of serpentine is about two or three hundred yards in width, bearing northeast and dips south). It occurs as an amorphous reniform incrustation on a brownish green, granular serpentine, in which are crystals of chrome iron. Its hardness is about 3; lustre resinous; its color varies from an apple-green to a yellowish green, streak greenish white. In a matrass, yields water. B. B. nickel and silica. (Taylor, Philad., 1858).

sandstone No. I. A better way to show this difference of age perhaps would be to say that the Canada serpentines if properly placed should appear in Pennsylvania along the southern base of the Blue or Kittatinny mountain north of Harrisburg. None appear there. On the other hand the serpentines do appear near Easton in Pennsylvania on the back of an anticlinal or uplift of azoic rocks, precisely in the place where they ought to appear according to their position at the Maryland State line.

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Serpentine in "large bunches" is secluded in limestone, associated with talc[8] and other magnesian minerals in Northampton county as described by the Pennsylvania geologists,[9] the limestone itself being a white crystalline mass of granular limestone, granular dolomite and calc spar full of specks of crystallized and semicrystallized graphite and replete with a variety of other interesting minerals in solitary crystals or in bunches and veins; some of them true veins of feldspar (sand 65 + clay 20 + potash 15) edged with crystallized mica and graphite, and some of them tolerably pure labradorite (= sand 55 + clay 25 + lime 11 + soda 4). As to the serpentine (sand $1\frac{1}{2}$ magnesia 1 and water 1) Mr. Rogers in his Final Report says that its presence with talc and other magnesian minerals "naturally suggests a possible origin by segregation, either in full or in part, from the dolomitic layers of the original magnesian limestone," but previously he expresses igneous convictions as plainly as possible when speaking of the bunches and vein-like included masses as if "they had been elaborated from the materials of the gneiss caught in and melted up with more or less of the elements of the limestone;" and on the preceding page (224) he says that the small basins of limestone under description are "only outlying patches of the great Auroral limestone of southern Pennsylvania, folded, metamorphosed, disguised and mineralized by *intense igneous action*, or that transforming agency which invaded all the older formations of the district in which they occur."

On page 243 he is still more explicit, where, describing after Mr. Trego the calcareous slates and sandstone at the base of his auroral system (No. 2) near Easton, speckled throughout with greenish serpentine etc, or converted into white crystalline dolomitic marble, he adds "it would thus seem that the great agent of metamorphosis in this belt has been the *intense heat effused* during the intrusion of the great dyke of granite which forms the main body of the ridge" developing hornblende in the slates, vitrifying the sandstone, dolomitizing the limestone, and developing "serpentine, silicate of magnesia and in fine the talcous and other magnesian minerals which so greatly abound on both flanks of this remarkable igneous axis." Yet he goes on to adopt all Mr. Trego's description of the *double anticlinal* structure of the ridge without a suspicion of the structural impossibility involved in such a hypothesis. An igneous effusion of granite would have left another Mont Dor towering above the Easton hills like a giant among pigmies, and converted the whole face of the country into a widely different landscape. The topography of the trap dykes further south can be accepted upon igneous principles only on the supposition that they overflowed under water during the middle secondary era and grew cold before the rocks above them were laid down. So if this dream of molten

[8] It is obviously a stratified rock overlying regularly the syenitic belt of the ridge, p. 20, 5th An. Rept. The smaller ridge consists chiefly of serpentine and talcose rocks, bounded by limestone; some of the talc contains cubic crystals of sulphuret of iron and fine green serpentine, in which zircons are said to be found, p. 20, idem.

[9] See Final Report, vol. i. p. 225.

granite were at all convertible into reality it would leave untouched the magnesian limestones of a subsequent period. No granite dyke has ever yet been seen throughout the thousand miles of the Nos. II, III (Lower Silurian) valley. At no point has the limestone ever been seen so acted on and the site recorded. The mere limitation of the granite to the southern border of that valley is under the doctrine of probable chances a valid argument for its superior age. It is inconceivable that no one granite dyke of a subsequent age could succeed in fracturing back and overflowing into the valley itself. The outliers of limestone therefore to the south must owe their metamorphosis to another cause and of course to watery if not to fiery agencies. If so the granite itself and all the other metamorphosed minerals were changed by a similar watery and by no igneous agency. The serpentine is a true segregation in a moist warm mass, and not a product of fervent radiant heat. In this very double anticlinal of Chestnut hill near Easton (not the Chestnut hill near Columbia) and between its "two chief lines of eruptic matter, each composed principally of granitic rock" lie *stratified* serpentinous beds with various associated magnesian minerals and dolomitic limestones. This seems to be the only ground for Mr. Rogers's theory of the double anticlinal as he can only see a *collapsed synclinal* in the occurrence of these beds, but "the bedding and internal stratification of much of the massive serpentine and serpentinous gneiss is too obvious to be doubted." The sentences which follow on page 243 reveal the entire uncertainty of the writer's mind and the utter darkness of the ground to him, as he wavers now to the igneous and now to the aqueous view and in the end hands over to the reader the whole tangled argument to unravel for himself in these concluding words: "the serpentinous rocks even of the more central parts of the ridge exhibit a sort of stratification [Mr. Trego said the stratification was too obvious to be doubted], and this implies that a portion at least of the material called serpentine here [perhaps not rightly] was originally a sedimentary rock, but altered, the transformation consisting, most probably [we cannot say for certain] both [and thus the difficulty is avoided] in a segregation of its own elements, and an intrusion of true igneous mineral matter." A lucid statement.

A brown hematite gangue 4 feet thick traverses the Greifendorf serpentine in Europe and includes bunches of gneiss which show a change into brown hematite. The serpentine and eklogite are much weathered next the gangue. Lumps of gneiss lie about the fields and may have got into the gangue crack. But the red granite and hornblende contain enough more iron than the serpentine to account for the iron cement between the gneiss balls. Bischof quotes Fallou's observations to show the conversion of granulite into serpentine, against Müller's opinion that serpentine is a fire rock, and adds that he considers the proof made out from the stratigraphical exhibitions of the serpentine at Waldheim, etc. and that the veins across serpentine were all open cracks filled afterwards by aqueous solution.[1]

Serpentine veins characterize the boracic acid region of Tuscany in Italy, in which are pools or little lakes kept boiling with emanations of hydrogen like the geysers of Iceland and of carbonated hydrogen (which has not been detected in the geysers) with abundant precipitations of boracic acid. The tertiary rocks in which they lie consist of limestone (converted often into gypsum), micaceous grit and schistose clays, and are traversed by serpentine masses. The *soffioni* or impetuous currents of gas and steam which rise through these rocks are at the temperature of boiling

[1] Bischof, Geologie, ii. p. 1485.

point, but the force with which they rise suggests a pressure below involving the existence of a still higher temperature. **Pennsylvania.**
In the vicinity of the Monte Cerboli serpentine, the limestone is converted into gypsum, "and the traces of these ancient metamorphic influences may be followed up to the present emanations which are their last representatives and continue their work."[2] It is evident that an excessive degree of heat has nothing to do with a *chemical* change like that of carbonate into sulphate of lime, neither therefore ought it to be regarded as an element in the force which substituted the magnesia in the serpentine for the lime in the limestone. Silicate of magnesia can be infiltrated at 212° F. as easily as ejected at 2120°.

Serpentine and the protoxides of iron and manganese with greenish white talc and silicate of alumina and sometimes actinolite and chromic iron ore in crystalline grains, the whole mixed in with pure-white anhydrous carbonate of magnesia nearly pure, form that splendid and lasting marble Verd-antique discovered a few years ago and now extensively wrought in Roxbury Vermont, columns of which ten feet in length and one in diameter stand in the colonnades of the new Capitol at Washington[3]

Chromic iron occurs in Monterey county a short distance south of the Mission of San Juan in California, massive, of excellent quality, almost identical with the ore from Wood's pit in Maryland and like it partly covered with green coats and crusts of emerald nickel.[4]

The titanium in **titaniferous iron** is no more evidence of the locally igneous origin of titaniferous iron than nickel in a lump of iron is of its meteoric origin; nor as much; for Dr. Mazade of Valence has detected titanium with zircon, molybdenum, tin, tungsten, tantalum, cerium, yttrium, glucinium, nickel and cobalt in the mineral waters of Neyrac in France.[5]

A **titaniferous iron** ore vein occurs on the east branch Brandywine near Isabella Furnace Chester county Pennsylvania, in a gneiss rock; a specimen, black, metallic lustrous, foliated and granular, magnetic and polar, spec. grav. 4.95, analyzed 76.86 protoxide iron, 22.39 titanic acid.[6]

In Harford county Maryland on Deer creek **titaniferous iron** is mined (in chlorite talc), and the same ore occurs in neighboring localities, as at Mine Old Fields, and Scarff's (in serpentine.[7])

Chrome iron ore was found in Montgomery county Maryland some years before Ducatel reported in 1837 and cost the operators a heavy loss. Subsequently hundreds of tons were taken out, and a thick vein discovered about the head waters of the Seneca on Lyde Griffith's land, the ore yielding 35 to 40 per

2 St. Claire Deville and F. Le Blanc in Phil. Mag. 1858, p. 284, xxx.
3 Annual Sci. Dis. 1856, p. 327.
4 W. P. Blake, U. S. Geol. Sill. Journal, 1856.
5 Ann. Sc. Disc. Boston, 1853, p. 203.
6 Dr. R. E. Rogers's Fifth Ann. Report, 1841.
7 Ducatel's Report, 1837, p. 34.

cent of chrome. Stewart's analysis gave chromic acid 45.5, peroxide iron 45.0, alumina 7.5, silica 2.5. Seybert's analysis of a Chester county specimen gave oxide of chromium 51.562, peroxide of iron 35.140, alumina 9.723 silica 2.000. Beudant's analysis of a specimen from near Baltimore gave—Oxide of chromium 39.514, peroxide iron 36.004, alum. 13.002, silica 10.596.[8]

Tyron's mine near Sykesville Maryland is described by Ansted the English geologist, in a paper read before the Geological Society of London February 25 1857 and printed on the 242 page of the Journal of the Society. Like the Hiwassee iron-copper lodes which he describes in the same paper, this ore bed, or lode as he would call it, crops out upon a ridge several feet wide, composed of hard ferruginous quartz, with numerous crystals of magnetic ore. At the mine the string of ore varies in width from ten inches to as many feet. A shaft 60 feet deep yielded excellent protoxide and peroxide of iron. Further down the fine, pure crystalline ore became spotted and mixed with sulphuret of iron, and horses of dead ground came in to split up the vein. Sulphuret of copper came in on the upper side of the horses against the foot wall of the workings. The copper pyrites could be easily handpicked from the magnetic iron, silicate and carbonate of copper, and mundic, which were all mixed up together.

This is one of three parallel lodes all looking alike as far as shafted on. Still others have been discovered between these and the Blue Ridge, always occupying the crests of low ridges.

Carrol mine, which is probably on the Tyson lode two miles north of Tyson's mine, contains blocks of steatite. At Mineral hill and at Fenceburg, two and eight miles further north, openings have been made upon the same set of beds, the copper below being in all cases surmounted by a gossan of crystalline protoxide and peroxide of iron in a highly magnetic state, and inclosed in steatite and talc walls. The lines of ore across the country open and shut, so to speak, as though the ore went down in pipes at intervals, or issued from below not in a regular sheet, but in jets at intervals along the line. They all dip steeply to the east-southeast.

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[8] Ducatel, 1838, p. 5.

Virginia.

Near the picturesque Point of Rocks in the Blue Ridge gorge of the Potomac an enormous mass of hydrous oxide of iron (limonite) is quarried, between soft slates dipping east. Soft blue shale divisions split up the mass into several beds, and the masses of ore from 20 to 100 feet long are concreted around clay-filled cavities. Mr. Ansted thinks that this mass of iron ore is but the top of a vast copper lode beneath the surface. It certainly extends back from the river along the Blue Ridge range.

The primary ores of Virginia have not been described. The manufacture of iron in the country of the Blue Ridge and to the east of it where the primary, Huronian (and perhaps Laurentian) system is developed, although very old for the New World, has been as unsuccessful as in Pennsylvania. Of eighteen furnaces east of the Blue Ridge only one was in blast in 1856, and that for but half the year, making 760 tons in a region where the standing capacity was at least 20,000 tons per annum. The Potomac furnace on the Virginia bank of the river a mile below the Point of Rocks uses the extraordinary exposure of brown hematite which lies in such a way as to show that it is a decomposition of an ore bed in some other form, probably that of a sulphuret. Some authorities compare it favorably with the Chestnut hill ore near Columbia in Pennsylvania; others say the ore is injured by phosphorus. A new furnace in Spotsylvania county about 15 miles from Mansfield P.O. has been built on what is called a "good rich vein," but it is undescribed. Rough and Ready furnace (H. 155) six miles from Louisa C.H. has magnetic ore within two miles both east and west of it, and mixes it with brown hematite from two miles northeast. Elk creek furnace (H. 158) 25 miles north of Lynchburg, works a magnetic, 80 per cent, 4 foot vein, 400 yards west of the stack, and mixes with its ore, brown hematite from a vein a mile to the north of it from 4 to 20 feet thick and 100 feet deep, impregnated with sulphuret of zinc. Beargarden in Buckingham county, Stonewall and Lagrande in Appomatox, Oxford in Campbell, Saunders in Franklin, Poplar Camp in Wythe, Shelor's and another old furnace in Floyd and a third in Grayson, are all abandoned stacks, built to smelt primary ores no doubt, mixed with brown hematites. Carron furnace (H. 163) in Franklin county uses a sulphurous brown hematite. Union fur-

nace (H. 164) in Patrick county on Hales creek has a great variety of ores among which are some black, perhaps magnetic. West Fork furnace (H. 165) in Floyd county 7 miles east-southeast of Lynchburg mixed in 1853 the Union ores with some that had been exposed for 30 years and made superior iron from them, but these are all brown hematites. In middle Virginia a multitude of furnaces have been built along the Great valley between the Potomac and the Tennessee line, of which but 21 made any iron in 1856 and these only 13,000 tons instead of 30,000 as they should have done, and not one of all these furnaces are reported as using any ore but the brown hematite of the Valley limestone, Lower Silurian, No. II. It is not to be imagined that this immense stretch of Huronian rocks is barren magnetic iron ground. The resources of the Blue Ridge must some day be explored.[9]

As lately as in his **North Carolina** Report for 1856 Dr. Emmons says that in that State "the oxides of iron occur only in veins excepting where the mass has undergone certain changes. The mode in which ferruginous veins have been filled is clearly that which is assigned to trap or granite. Iron however in combination with chlorine is volatile and is vaporized and finally deposited in the condition of a peroxide or specular oxide." Specular iron is found in North Carolina in true veins.[1] No mistake can be greater. The specular beds of the middle south border of the State are too well described by Tuomey and Lieber to leave us in doubt of their sedimentary origin. By "certain changes" Dr. Emmons of course means the weathering peroxidizing, and especially hydrating influence which has deposited so extensively the brown hematite (limonite) iron ore and brown manganese ores which he describes on page 105, where he goes on to grant that "iron in a state of hydrous peroxide is not confined to the soil of the present; it is a deposit in beds in most of the systems of rocks, the Silurian, Devonian, Carboniferous and Permian;" but he argues that the original deposits, volatile in the presence of water and sulphur, were introduced in a state of vapor into the fissures of the earth's crust and became incorporated with the porous wall rocks.

In **North Carolina** beginning at the western part of the

[9] Bulletin, A. I. A. 1858, p. 113. [1] Emmons. Page 84.

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midland counties, which are traversed by **three belts of magnetic ore,** changed in some places to specular, the first belt, says Dr. Emmons, passes from six to seven miles east of Lincolnton, and is prolonged into the King's mountain range of Gaston county, southwestward. His section No. 1, plate XIV shows a flat country of gneiss towards the east, broken up though by a vein of manganese (!), and a mass of coarse granite on the west. Into the deep geological gorge conceived to exist between the two, plunges a vertical plug of "Taconic rocks" with the following arrangement from west to east:—Slate, limestone, slate, limestone, slate, granular quartz, slate, granular quartz, graphite, mica slate, iron ore against the wall of gneiss. The probability of these rocks being the three members of the Lower Silurian System Slate III, Limestone II, Sandstone I, with the iron ore of New Jersey, New York and Pennsylvania, in its proper and regular place, at the top of the gneissoid or Huronian rocks, is evident at a glance. Lincolnton is on the coarse light grey micaceous "granite." The ore is in a thin bed of talc slates and the granular quartz sandstone is a marked rock traceable from the Catawba river into South Carolina. The beds of ore are seen on the north side of the plank road seven miles east of Lincolnton. The limestone is a mile west of the ore. The ore is usually near the crest of a ridge, or traverses parallel ridges very obliquely; "there is no instance in which the vein runs precisely parallel with a ridge or follows it; it makes in this instance towards the east," bearing N. 20° east as the strata do. [This shows that the ridges do not obey the stratification, and that the ore does.] The veins of Lincoln county are lens shaped, with knife edges lapping each other; increasing from nothing to 6 or 8 feet thick in a length or depth of 50 or 60 feet. Dr. Emmons says each oval mass invariably sets back against the foot wall of the mass above it. But evidently that will depend upon the way the miner moves. The ore is usually fine grained; rarely coarse; soft; breaking readily and crushing in the hand, from being mixed with talc slate; strongly magnetic; easily smelted; upper portions of the vein disintegrated to a loose red mass, powdery; interior, black granular. The veins have been wrought for many years and have made a celebrated iron, strong and tough. Brevard and Johnson are the chief owners.

This range of ore prolonged appears next at the **High Shoals of the Catawba** with the same rock relations, but the ore somewhat changed. **Ferguson's Bank** gives a snuff-colored brown hematite decomposed from a very pyritous gangue ore, and making good casting iron but bad bar unless entirely decomposed. **Ellis's Bank,** three miles from Fullenwider's old furnace in the direction of King's mountain gives a black ore in a vein 18 feet wide, N. 20° east, an inexhaustible supply of good iron. **Carson Bank,** the most easterly, gives a common black magnetic ore, curiously jointed and breaking up into angular fragments. The belt continues to King's mountain where **Briggs vein** is 40 feet thick. Iron has been made here for half a century. Beds of Hematites occur near the top of the mountain. Crowder's mountain, near its top, furnishes the same in a specular vein 6 to 7 feet wide. No doubt between Sherrill's Ford on the Catawba and Limestone Springs on the Broad river in South Carolina many more exhibitions of these ores will yet be discovered; but the resources of the present are so vast that no inducement is held out to active exploration. In Lincoln county a fine bed of hematite exists two miles southwest of Lincolnton.[2]

In **Lincoln county** three furnaces are running on these magnetic ores, Rehoboth, Madison and Vesuvius, the first using Leiper's creek ore and using the iron for castings, the second using the same ore two miles distant and applying the metal in the same way, and the third using the same ore from the same bank. Madison, Springfield, Mount Tirza and Mount Welcome Catalan forges all bloom up the ore from this celebrated Iron Bank. In Gaston county Columbia furnace, now abandoned, used a *nickeliferous* magnetic ore mined close by. It will go again into operation accompanied with rolling mill and forges. Brigg's bloomaries work up ore in their neighborhood.

In **Cleveland,** further west and in the natural range southwestward of the Stokes and Surrey ores, six bloomary forges are in active exercise making from 12 to 109 tons of iron per annum each. Dixon's on Knob creek, 12 miles northwest from Shelby; Buffalo Shoals, Froneberger's, Buffalo, and Buffalo Iron Works, all on Buffalo creek, make their ore from Brigg's Yellow Ridge Bank, grey magnetic ore from under the west side of King's

[2] Emmons's Report.


LAKE ERIE
FURNACILLING MILLS
WESTERN
YLVANIA
& CONTIGUOUS PARTS OF
MARYLA
GINIA.
OHIO.
CHARCOAL FURNACES
ABANDONED FURNACES
ROLLING MILLS
RAILWAYS

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mountain. The first of these four uses a leaner distant ore and is to be abandoned in consequence. The last mixes three magnetic ores. Lastly Stice's Shoals bloomary on First Broad river three miles north of its mouth, works up Ormond's magnetic ore.

In **Rutherford,** Tumbling Shoals bloomary works up the red specular ore 13 miles southeast of the county seat.[3]

The Second Belt of North Carolina primary ores in the Midland Counties begins say in Montgomery county, crosses Randolph near Franklinville and Guilford 10 miles west of Greensborough. Mr. de Berri's ore is 7 miles southwest from Troy, in a pine forest, and related to the rocks thus:—Gold or Talc slate, Quartzite, Ore, Agalmatolite, Talc slate. The beds are traversed obliquely by a narrow bed of hornblende. The mass of ore is 50 feet wide, occupying a knoll or low hill and traceable a quarter of a mile, silicious at the surface, with subordinate seams of pure heavy peroxide, strike N. 30° east, dip steep northwest, jointed, breaking angularly, non-sulphurous.—Four miles **north of Troy,** in the same range, and near the Carter gold mine, is another series of veins of magnetic ore much of it octahedral, very friable, intermixed with talc slate and quartz grains; the beds differing in composition from one another, a bed of specular ore lying side by side within a few feet of one of magnetic ore.—The **Davie county** and **Stokes county** ores, the distant observed points lying in direct lines parallel with the limestones and slates, are prolongations of the Lincoln county belt, but Dr. Emmons could not trace these rocks across Catawba and Davie counties, for after crossing the Catawba we lose the guides above mentioned. He has some doubt also about the age of the Germanton Limestone, supposing it may be different from that of the Kings mountain limestone. The continuity of the line is better preserved in the South than in Davie and Stokes. Three or four miles southwest of Franklinville and near Deep river heavy black massive magnetic ore lies in abundance loose about the uncultivated surface, near a fine ore bed, removed but a short distance from the quartzite outcrop.

In **Stokes county** four bloomary forges within ten miles

[3] Bulletin A. I. Ass. notes to tables H and I. B. S. Lyman.

around Danville work up magnetic ore. Two of them are in or opposite the town, Frost's has been abandoned six years, but Keyser's six miles northwest of Germantown is in use again, its ore is close by.

A magnetic ore bed one mile from Danbury is reported by G. J. Philips in 1856, J. Pepper and E. Emmons, to be 6 feet thick, nearly vertical, strike northeast, percentage of iron 77, depth of shaft 57 feet. The Dan river coal basin is within ten miles. There is a belt of magnetic ore veins through Stokes county 6 miles long by 2 or 3 wide in gneiss and mica slate, and dipping very gently. Rogers's bank 3 miles from Danbury has long been wrought.

In **Surrey** are six bloomaries, and one furnace, now in ruins. Hill's forge with the Tom's creek furnace near it, Fulk's (abandoned in 1853), Hiatt's upper and lower, Blackwood's and Cooper's all make small quantities of iron from magnetic ore found in the neighborhood. Hill's vein on Tom's creek 5 miles from the Pilot mountain runs from 7 to 17 feet thick, 67 per cent, dip 40° northeastward. Blackwood's ore is near his forge on Fisher's river. (*Bulletin.*)

In **Yadkin** three bloomaries, Hobson's two and Forbush's use neighboring magnetic ore, on Forbush creek, 5 miles east from Yadkinville. (*Bulletin.*)

In **Catawba** two bloomaries Mount Carmel and Rough and Ready both on Mountain creek 12 miles southeast from Newton, get their magnetic ore all along the south side of Mountain creek, and a third, Jenny Lind on Maiden's creek 6 miles south from Newton, gets a very rich ore from three miles south of it.

Specular ore was discovered and shafted on **near Trogden mountain** many years ago before the present settlers came. " Old crucibles and furnaces still attest the unprofitable industry of some expectant of a fortune in the splendid lustre of this specular oxide of iron." In **Guilford county** ten miles west of Greensborough between Brush creek and Ready Fork, several veins of black and middling coarse, valuable, magnetic ore, unmixed and pure, have been long known. Dr. Emmons remarks that in the New York mineral districts a crumbly ore is expected to make a soft, and a hard tough shining ore a hard, intractable iron. This is a dull and very heavy ore, apparently running in two parallel veins, with magnet outcrop (each piece

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having two or more poles of attraction and repulsion) running northward from Coffin's, through Harris's plantations to Morehead's on the Troublesome, "where it is in great force," and southward through Chipman's and Unthank's. It is therefore a separate subordinate belt.[4]

The **Third Belt of North Carolina primary ores**, the eastern or Chatham belt, is the least regular. Specular ore crops out on Evans' ridge four or five miles from the Gulf of Deep river on the plank road leading north, as an eight foot vein in talc slate, connected with amalgatolite or figure-stone (called soapstone in the neighborhood improperly, for it has no magnesia) a rock associated with these Carolina iron ores. Another seam exists on Glass's lands near by, as crystallized specular ore. Not far off is Ore hill, a famous locality of hematite traversing a knob 300 feet high in east and west belts in talc slate, quartzite forming the pinnacle of the hill. Here old excavations show where in the times of the Revolutionary war the large concretionary masses of ore were extracted. Magnetic ore is found on Heading's place, resembling Coffin's ore. T. Unthank's magnetic ore vein from one to three feet thick is two or or three miles beyond Evans's bed and one mile off the plank road. In **Johnston** county four miles west of Smithfield is a large deposit of hematite near quartzite. In **Wake** county eight miles southwest of Raleigh is a similar bluff of hematite in clay slate and chlorite slate at Whitaker's. In **Orange** county in the Red mountain range extensive ore beds are reported by Mr. Gillis of Granville county.

Carbonate of Iron occurs in many places in North Carolina, but in combination with copper pyrites. It is very common on the head waters of the Uwharrie near Gen. Gray's. At Johnson's a vein of it containing gold, but pure enough to work for iron has been exposed in several shafts.[5]

In **Ashe county** in the extreme northwest corner of North Carolina among the Backbone mountains of the Blue Ridge range there were once nine bloomaries at work; only three remain, making from 5 to 15 tons a year apiece, Helton's, Little Elk and Little River, on streams of the same names. But these forges run on so-called fine hematite ores, whether red or brown

[4] Emmons's Report.

[5] Dr. Emmons's Report of 1856, p. 127.

is not stated. The banks are numerous however. In **Watauga county** three bloomaries make *together* less than 15 tons a year. The Cranberry creek bloomary bank (on a branch of Elk creek) has a " very superior, 80 per cent, magnetic ore bank within a mile south of it, and another 60 per cent ore bank half a mile further." The Toe river forge directly opposite the Cranberry forge across the mountain ridge and Johnson's forge three miles still higher up Toe river, drew their supply from the Cranberry bank, but latterly have opened a magnetic vein one and a half mile north of Johnson's. In **Cherokee county,** at the extreme southwest corner of North Carolina are six bloomaries. Lovinggood's and Little Hanging-dog on Hanging-dog creek use lump or brown hematite. Fain on Owl creek at the mouth of Hanging-dog and two miles from Lovinggood's uses the same ore which is said to work easily and well, unwashed, yielding 35 per cent. The Persimmon creek and Shoal creek bloomaries use red ore from Kilpatrick's bank, which is 27 miles east of Ducktown in Tennessee. The ore is probably the brown hematite outcrop of a double sulphuret vein like the Ducktown veins.[6]

In **South Carolina**, the First or Lincoln primary ore belt of North Carolina, entering York District, crosses Broad river between Buffalo and King's creeks at the Cherokee ford and Ninety-nine islands into the Spartanburg District.[7] The magnetic and specular ores, says Prof. Tuomey the State Geologist in his Report of 1848, from which the most of what here follows has been taken, are chiefly confined to a narrow belt of slate in York, Union and Spartanburg districts extending along the northern side of King's Mountain, and terminating at the head of People's creek, a distance of six or eight miles, being underlaid by the lime rock and surmounted by the mica slate of the King's Mountain range, strike N. 50° east, dip 45° to 70° southeast. [It is possible therefore that these dips are all overturns, and then the iron and primal slates will properly underlie the Lower Silurian Limestone.]

The Grey Magnetic ore beds occur intercalated among the layers of a band of talc slate never more than half a mile wide,

[6] Of which hereafter, p. . Bulletin A. I. Ass. 1858, notes, p. 140.

[7] See Tuomey's Report. Map on page 80. See also Lieber's map of 1857.

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and follow the foldings and irregularities of the slate. They are therefore pure chemico-sedimentary deposits and lie in lenticular form, swelling out to 15 or 20 feet and diminishing again to nothing; lying side by side and yet so insulated that one bed may be entirely worked out without giving a clue to the existence of another lying within a few inches alongside; the lenticular structure being as much vertical as horizontal. Not only is the ore contemporary with the slate but graduates into it so as to be distinguished from it only by its greater weight, and must therefore have been deposited with it.

The ore appears on the bold shores of Broad river down to water's edge, yet all the workings were, at least up to 1848, mere surface strippings on the hill country above. The disintegrating, friable character of the ore makes a smooth weathered surface, marked only by a few rusty pebbles. Sulphuret of iron was seen by Prof. Tuomey at but one opening, on Blackrock creek half a mile above Quin's on the left bank of Broad, where parallel quiet slate walls inclose several beds of compact hard tough brilliant black granular highly magnetic and polar massive ore, almost unmixed with foreign matter, of considerable thickness. Ore occurs at Quin's; and ore has been got for the Nesbit Manufacturing Company near Cherokee ford, in some fine beds. Other beds have been shafted on, a few miles beyond Quin's, all of them in black friable ore. The talc slates extend a few miles further, narrow and disappear. This shows either a synclinal or anticlinal structure. The section which Tuomey gives on page 79 would go to show that the anticlinal structure is the true one, for he there exhibits the great quartz rock of King's mountain dipping southeast, and under it, the North and South Carolina outcrop of red and specular iron ore next to be described; under this, the gold ore and iron ore rock; and under this, the talc slates with their grey magnetic ore; under this, the flexible quartz or Itacolumite, and under this, limestone in the centre of the axis, on the opposite slope of which he places iron ore again. But the section is radically defective on account of the impossible radiation of the central dips. We cannot therefore decide between a vanishing anticlinal carrying the talc slates under, southwards, or a vanishing collapsed synclinal carrying them into the air, southwards.

In other parts of South Carolina Tuomey found indications of valuable magnetic ore; in Chester District near Cornwall's large masses of compact ore in hornblende; a few miles northwest of Abbeville; on Hardlabor creek, near a bed of peroxide of manganese.

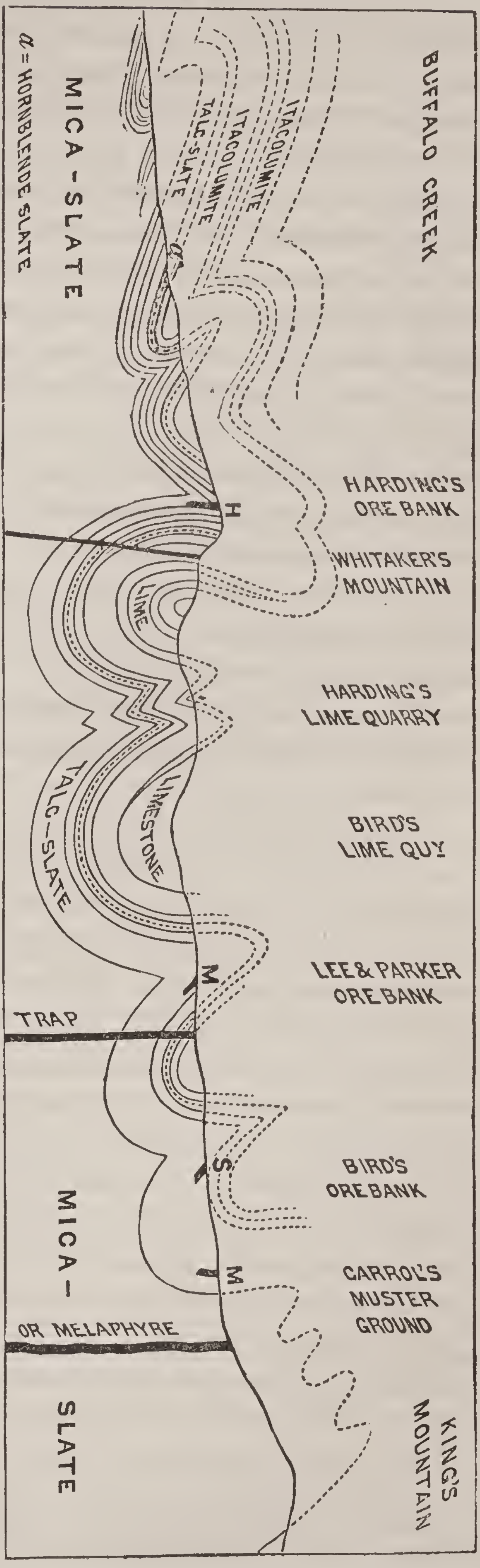
The mines yield three varieties of magnetic ore. 1. The dull, dark, pulverulent favorite ore of the furnaces and forges, disposed to be lamellar, easily mined and easily wrought although not so rich. 2. The granular ore, in masses of cemented grains of small size and partly crystalline, containing 86.00 peroxide, 12.00 insoluble matter and magnesia and a trace of manganese, and yielding 60 per cent of iron when washed. 3. The compact, pure bed-ore, hard and tough, highly metallic and magnetic, containing 91.00 peroxide, 8.66 insoluble, 0.34 oxide manganese, and yielding 63 per cent of iron. One variety of ore from People's creek seemed largely mixed with oxide of manganese.

The specular ores of South Carolina lie in a belt of mica slates immediately overlying the talc slates containing the magnetic ores,[8] and forming the northern slope of King's mountain, from the North Carolina line to Gelkey's mountain in Union district. A similar bed of mica slate, upon the other side of the anticlinal, dipping southwest and overlying the limestone of York district, contains similar beds of specular ore. Prof. Tuomey gives on page 82 a diagram showing two closely folded collapsed and overturned anticlinal waves in the mica slates, including and folding a regular bed of ore, double in structure (like a double coal-bed) black (with a red streak) with thread-like veins of quartz running through it. Its locality is known as the Bird bank a little north of Meadow branch of King's creek. On the north side of Gelkey's mountain the ore is in bent slate, and the quantity very great. Near the King's Mountain Furnace is a bed two or three feet thick, distinctly laminated and breaking into rhombs. Near the surface it is red and rather pulverulent, particularly on the surface of the laminæ; lower down and further in it becomes grey and somewhat magnetic; still lower or further iron pyrites appears and spoils the vein. This reverses Volger's law of metamorphoses which puts the magnetic form after the red hematite. It also assimilates

[8] Does the extra iron in mica over talc account in any degree for the more perfect oxidation of the ores in the mica slates over those of the talc slates?

these red hematite beds with the composite pyritous beds of Polk county Tennessee, and elsewhere, and takes another step across from the sedimentary to the primary phenomena. Near the Iron Works on Dear Little creek red oxide was once got in abundance, and numerous exposures may be seen on the mountain spur. Here comes in the Bird bank mentioned above. Directly west, on Jumping Branch is Hardin bank, strike N 50° East, dip 45° to 80° northwest, 3 to 4 feet thick very uniform, planes unusually straight for micaceous rocks, regularly interstratified with the slates, splitting readily into laminæ, ochreous (red and yellow—hydrated) at the surface, for 20 feet in, then grey with reddish streak, somewhat magnetic; at water level pyrites appears, and native sulphur coats the fissures. Ore compact, composed of small slightly cohering grains, with a dull grey lustre except where crushed; there red. It was, says Tuomey, originally a pyrites bed and is so still no doubt at a sufficient depth. In all the gold mines of the State iron occurs invariably as pyrites. The ore ranges on from the Hardin bank in the line of

South Carolina.



strike.[9] The structure of the surface for 8 miles west of King's Mountain is shown by the section in Prof. Lieber's Report of 1857, in which at least eleven folded axes appear, of a shape to demonstrate a gentle side thrust, and subversive of any law of wave movement such as Prof. Rogers has fancied. But what is remarkable Lieber assigns a place to all the banks along the line of section, Carroll's, Bird's, Lee's, Dr. Barker's, and Harding's, in the mica- and not in the talc-slate ground. As this is the first instance of a clear section given by any American geologist fixing the ores in their stratigraphical relationships to these obscure and much debated rocks it is given on the preceding page.[1]

The rocks of the older formations according to Lieber are:

Clayslate . . .	Limestone, Itacolumite, Specular schist,
Hornblende slate . .	Talcose slate, Mica slate,

but the relations of the clay slate and Hornblende slate in the one part of the State to the five corresponding rocks is a matter of obscurity. Tuomey considers the clay slate of Chesterfield and (southeast)

[9] Tuomey's Report on the Geology of South Carolina 1848, p. 83.

[1] Lieber is one who values the labors and quotes the works of Fournet,* Combes, Delesse, Von Weissenbach, Zimmermann,† Bischof, Cotta, †Gätzschmann and Breithaupt§ condemns the superficial English theorizing on the origin and nature of veins as mere accidental occurrences, condemns Delabeche for believing in the secretion of the gangue mineral from the country or wall rock, condemns the believers in the igneous origin of the gangue rock which as he says resembles no igneous rock known, praises (and justly) Whitney's book as "the first real attempt at commencing a mining literature in our country," but adopts the hypothesis of Werner modified by Elie de Beaumont‖ and others that "veins are filled crevices (a fact now universally admitted") supplied with solutions drained into them, not from the surface as Werner supposes, but from the interior of the planet, mineral waters, hot springs, steam, the surplus only of which went up into the surface waters and was floated off and precipitated elsewhere; Cotta showing how the same precipitations were made upon both walls at the same time, and different precipitations in the same order, the order of their solubility. Lieber applies these views to the explanation of the successive gold-lead-copper appearances in a peculiar class of South Carolina veins, and assures us the old genetic causes are still at work. He denies any distinction between cross veins and bed veins, as cracks may occur in any direction. He gives a vocabulary of the technical terms in French, German and English vein mining, notices the electrical experiments of Reich and Fox and closes his introduction with a discussion of the gossan or outcrop sign of veins.

* In his Simplification de l'étude d'une certaine classe de filons, and vol. iii of d'Aubisson de Voisins and Amadée Burat's Traité de Géognosie, Paris 1828, 1834–5. † In Wiederausrichtung Verworfener Gänge. ‡ Ganglehre und Gangstudien. § Auf und Unter-suchung der Lagerstätten Nutzbare Mineralien. ‖ French Geological Soc., 2 series, vol. iv. p. 1249.

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Lancaster possibly palæozoic [Lower Silurian; No. III; Hudson river?]; it underlies the tertiaries, and becomes talcose as it approaches the talc slate region. The specular schist,[2] the rock which is mined as an ore west of King's mountain, is a companion to the itocolumite here, as in Brazil. It is an exceedingly rare rock only known in the Brazils, Marmoras and Provence. Here it lies between talc slates. The Bird bank shows it in typical form, and it can be traced along the southern limestone outcrop southwestward to the two ranges of hills bounding Dolittle creek, Dolittle and Silver mountains. On the former hill a quarry crosses it 40 feet without interruption, the whole hill consisting of alternate quartz, talcose and specular schists, the greatest thickness of the latter being between the itacolumite and talc slates, dipping 64½° S. 49° east, but the quartz rocks folding so as to dip 90° N. 5° east and the talc slates 90° N. 11° east. The ore gives out east of Harding's. On the Dolittle mountain it is perfectly developed and characterized, looking like mica schists, steel grey, but betrayed by its streak. Further north it grows less schistose and more granular and more talcose, and a little magnetic, weathering to brown hematite. It is the *itabirite* of Eschwege, but with less quartz and more talc than at the peak of Itabira in Brazil. It is essentially talc (or chlorite) strata charged with the crystals of magnetite, alternating with strata less charged. The needle is not affected. The bed which is opened at Lee & Parker's and by the Swede Company in the corner of Union are in the neighborhood of dykes of melaphyre or of diorite, which may have produced the magnetic ore locally [but common decomposition is sufficient to account for the charge]. The Lee & Parker bed is underlaid by a barytic vein of unknown width, which cuts off the bed sometimes, and also strings into it. Here occur mesotype, hyalitic quartz, chlorite, pure talc, asbestus,[3] staurolith, and sulphate of iron. The bed here dips 60° S. 43° east, and runs northeast to the east of the summit of King's mountain in North Carolina, in one or two places underground, that is with no visible outcrop, but the connection is established by a curious

[2] Siderocriste, Eisenglimmerschiefer, fer oligiste micacé.
[3] Compare the New York Stirling mines, page 411 above.

fact. When Briggs sunk his deep pump shaft at his North Carolina gold mine, the Parker and the Lee banks 14 miles distant were entirely drained, filled again when his pump stopped and were again drained by Commodore Stockton.[4] These ores with charcoal yield an unrivalled steel, and an English Company were lately securing possession of the region.[4]

In Spartanburg district are five furnaces of which Cherokee has been long abandoned, and Ellen and Susan have made nothing for some years. Hurricane on Pacolet river 7 miles east-northeast of Spartanburg uses red hematite, 60 per cent, ore from a bank 4 miles northeast, on a ten mile railroad into the iron and charcoal district. Cowpens on Cherokee creek 3 miles south of the State Line gets its ore from near the Hurricane banks. The Twins on Broad river, 26 miles northeast of Spartanburg, mix magnetic and hematite (red?) half and half.[5]

There is a bed vein of iron on Nanny's mountain in York district much resembling the copper-iron veins of Ducktown, having a porous hematite gossan 5 or 6 feet wide descending steeply into the mountain, between gneiss rocks. Here an old furnace and bloomaries were once at work but made poor iron.[6]

These **Ducktown** Polk county **Tennessee** veins extend into Virginia and into Alabama in the wide open hill country belt between the Alleghany mountain and the Blue Ridge. They are a porphyritic mass of iron and copper pyrites, the latter being the matrix, although the cubes of the iron excel in bulk. This porphyritic structure however is not so well marked in Tennessee as in Georgia. This mass fills the vein to the exclusion of other minerals, although quartz is sometimes found on one or both walls. Recent explorations by English companies at Ducktown to a depth of 400 feet show a gradual increase downwards in the value of the copper ore and a diminution of iron pyrites.[7]

The Hiwassee or Ocoee mines of Polk county in the southeast corner of Tennessee, are as much iron as copper mines, and an iron furnace was once erected to smelt the ore. The region is a prolongation of the Blue Ridge of Virginia, and subject

[4] Lieber's Report of 1857, page 92.
[5] Bulletin A. I. A. Notes, p. 113, 1858.
[6] Lieber's Report 1857, p. 84.
[7] Lieber's Report, p. 83, South Carolina, 1857.

Tennessee.

to all the same conjectures of geologists—a country of talc and chlorite slates, garnet rocks and steatites, hard mica sandstones, crystalline and porphyritic, as well as marble limestones, like the same range so well studied by Logan and Hunt in Canada and in Vermont, as the altered rocks of Lower Silurian I, II, III and IV, from Potsdam sandstone up to Shawangunk grit. The strike is N. 30° east, and the dip of the veins to be described is nearly vertical S. 60° east. Northwestward descending the Ocoee river through closely folded undulations of every steepness of dip and a thousand changes of rock from almost granite to almost marble, we approach the great valley of eastern Tennessee and middle Virginia, filled with indubitable Lower Silurian (Trenton, etc.) Limestones. But near the mines, quartz strings range along the strike between the mica slates. These Ansted calls neither dykes nor beds, and says that they are sometimes seen crossing the rocks at right angles. At intervals along the quartz strings, which remind one of segregations, occur, upon the surface, outcrops of porous dark brown iron ore, and the rocks on each side of these also become ferruginous. Occasionally magnetic iron ore is seen and the surveyor's compass fails. The connection of the mines, or what is the same thing, the continuity of the veins can scarcely be made out, because the enormous expansions of the outcrops of the Hiwassee (30 feet) and the Isabella (250 ! feet) are quite local. The Tennessee mine seems to be a continuation of them both united southward, but is at its thickest only from 12 to 18 feet, and the Polk county lode, its parallel, is from 20 to 40 feet thick. Mr. Ansted calls these four parallel lodes, and says contemptuously of "Mr. Whitney and some American geologists" that no very satisfactory account has yet been given of these singular deposits. His own account published on page 253 of the Geological Society's Journal for February 25 1857 is a model of non-committal obscurity, open to exception for the worst faults of the Cornish observers, when they travel off their own ground. It is evident to those who are accustomed to work, not in rifted primary regions, but in sedimentary palæozoic and metamorphic regions, that much if not most of the fire-worship in geology must be given up; that the majority of so-called *ejected* subterraneous metallic veins were in fact *injected* from above, or else were

original layers in the system of deposits. The perfect conformity of these mineral masses with their including and quartz slate walls, is the best argument for the latter supposition; while many geologists and chemists of high standing are preparing to show the process of subsequent precipitation from an overlying metal charged ocean or lake water, into fissures gaping upwards only at intervals along their jagged lines.

Whether original lenticular deposits metamorphosed and uptilted, or ejections from below, or injections from above, these immense beds are found to consist of a double sulphuret of iron and copper wherever they are mined down low enough to be examined under the lowest water level of the neighborhood. Above that level however they show themselves in a dilapidated or decomposed condition. Their outcrops run along the summits of narrow ridges as we might expect them to do, seeing how much harder the compound ore and its quartz walls are than the slate rocks on each side of them. The rains have decomposed the pyrites, dissolved and carried off the sulphur in the form of free sulphuric acid with sulphate of iron and copper, leaving the skeleton of the vein a porous bed of dark brown hematite with an irregular cross layer at the bottom, at water level, where the lees would settle, of black oxide of copper, under which lies the untouched double sulphuret of iron and copper, the original unchanged vein.

Mr. Ansted says that in one place where sinking was done upon this floor ground, at the depth of 17 fathoms the vein-stone became calcareous, but remaining 30 or 40 feet thick and very hard, while the foot wall rock grew softer. If this is an index of anything it intimates the terminating of the ore deposit downwards.

The irregular cross layer of soft black copper ore always struck in going down below the gossan and above the floor ground, and varying from a few inches to fifteen or twenty feet in thickness, but not more than five feet on an average, is evidently the lees or drainage from the crop down to water level, since it rises going in from water level, and thickens also according to the greater quantity of ore originally above it, or according to the height of the breasting of the vein. In the Polk county vein Mr. Ansted says this is not so.

We are here interested in it however only as it has left above it immense quantities of the dark brown oxide of iron, which will some day become of value, while it contains itself as much iron as copper, mixed with too much sulphur to be used. Ansted gives the following average analysis of six specimens made by T. H. Henry:

Sulphur 29.47 Copper 26.73 Iron 26.04 Quartz 8.60; + 9.16. Mr. Ansted sums up the resemblance of these beds to foreign metalliferous veins thus: 1. They have unchangeable walls; 2. a characteristic quartz or calcspar vein-stone, passing to outcrop as ferruginous; 3. abrupt ends and no bottom; 4. parallel sub-veins and branches; 5. a nearly vertical and regular dip. On the other hand they differ

from common copper veins 1. by not crossing, but conforming to the strata in strike or direction and also 2. in steepness of dip; 3. they contain lenses of the wall rock, as if they were interstratified with the schists that include them; 4. they are cut across by the soft black oxide, which lies in hollows in an edge beneath the true edge of the vein, and which, 5. thickens with the height of the surface above. In four of these particulars they resemble the gold veins of Virginia and the Carolinas.

Tennessee.

Now in the first place Mr. Ansted is wrong in arguing from the "apparently unlimited depth" of these veins in comparison with their "limited extension in length and width," for they have been traced one or two miles, and not sunk upon more than the sixteenth of a mile. The Isabella lode is 600 yards long and 75 yards wide and no one knows how deep beneath the base of the hill along the top of which its outcrop rides. Its depth may not be any greater than its width, to say nothing of its length. If it be not an originally horizontal precipitation of the age of the magnesian schists in which it stands now vertical, there is no difficulty in conceiving it to be a crevice gaping upwards and filled in from above. Mr. Ansted reveals a singular incompetence to argue the question here presented, when he writes a sentence like the following: "These Ducktown lodes must not be considered without special reference to the physical conditions of the adjacent country. [Of course: what geologist would think of doing so?] They are amongst the old rocks of the main Alleghany chain, but not very near any large masses of igneous rock. [The main chain is carboniferous. But are these Silurian, Huronian or Lawrentian? that is the only question.] The general form of the ground as far as regards the ranges parallel to the main axis, is unquestionably due to elevatory causes [of course: for all the rocks stand on end or roll in an endless series of waves], and not to denudation [!]; but it would be difficult to decide without very minute investigation, whether the transverse cuts through which the natural drainage is carried are partially or entirely the result of weathering and aqueous action, or are due to transverse elevations. No faults or heaves have as yet been observed in the district and no cross-courses are known that intersect the gossan-lodes."

This extraordinary paragraph, to call it by the gentlest term we have, is followed by another beginning: "No very satisfactory account," etc, the words which have already been quoted. The fact is, on the contrary, that nothing is more evident at a glance to the American geologists, than that the whole surface of the country under description has suffered as much and of the same kind of denudation as all other portions of the Appalachian mountain region from Quebec to Tuscaloosa. A man coming over from England to look about him among the relics of a world of decapitated anticlinals, for a month or two, stands of course bewildered and stupefied, and returns without receiving any very clear ideas, to the land he is accustomed to, a land of lodes and faults, elvans and cross crosses. But when there, he should hesitate to ascribe his own natural perplexities to those who have studied long and see clearly and feel quite at home where he was quite at fault,—to those who feel the ignorance involved in the very suggestion of "transverse elevations" *between* the "transverse cuts" or water-courses, however doubtingly advanced. The ribs of quartz rock, the planes of mica slate, the outcrop gossan of the veins, rise plainly before us from hillside to hillside and can be followed innumerable miles, from stream to stream, without a suggestion of such an idea, as *cross* disturbances between the transverse streams.

Here is the point,—not that Mr. Ansted reasons wrongly like other Englishmen about a country much unlike their own,—but that these veins were once much more

elevated, when the country itself was so, and before the universal denudation took place, which has formed the present topography, and the outcrops as they now are. At that time *if ever* the veins received open-mouthed their precipitation from above. But much more probable is it that they were original deposits like the phosphatic magnetic iron beds of Essex county New York, and and the equally old Iron Mountain and Pilot Knob beds of Missouri, which no one can sketch or see a good sketch of without feeling that they are no true veins, or of a later date. Then, when the uptilt took place, when the denudation followed, when the cross streams had been notched out and nothing but the alluvial polishing was to do, the leeching process began, which has advanced to a point at which our shafts and tunnels enter to take advantage of it.

The reader will forgive this long discussion and its personality, for the sake of American science and the subject itself. The first often requires but seldom obtains even a feeble defence. The second needs in this division of it all the light that it can get, and after all there will not be too great a glare.

The new copper mines of Carroll county Southern Virginia which were traced and opened after the Ducktown Tennessee mines were producing their feverish effect upon the market are well described by C. S. Richardson in the November 22 number of the London Mining Journal for 1856.

In Cocke county Tennessee, on French Broad and Big Pigeon rivers, the primary granite, gneiss and overlying silicious slaty rocks and granular limestones of the Smoky mountain dividing Tennessee from North Carolina may be examined best. They abound in veins of iron, manganese and zinc, with chalybeate springs. On Long creek branch of French Broad are numerous veins one of which furnished ore to Legion furnace (II 272). On Grass Fork and on Stone's creek ore is abundant, with black oxide of manganese. On the Dry Fork of Wolf creek it may be traced for miles in great abundance on both sides the State line.[8]

Into **Georgia** the North Carolina and the Tennessee belts of primary rocks pass over, the former among the mountains of **Habersham county** where the Sequee creek furnace and forge, 3 miles south of Clarksville, once operated (abandoned in 1837), and the Mossy creek bloomary 18 miles northeast of Gainesville still works up brown hematite ore, although magnetic ore is supposed to exist in the neighborhood. The Mossy creek bloomary 10 miles southwest of it shares its ore. This is the Chatahoochie iron region alluded to by Whitney and examined by Hodge.

The westernmost belt of North Carolina and Polk county

[8] Trost's Geol. Report of 1840.

Tennessee (Ducktown) ores runs down into Union, Fannin, Murray, Walker, Cass and Dade counties **Georgia.** The Ivy Log creek bloomary in **Union county** is abandoned. The Hemptown creek bloomary a mile northwest of Morgantown in **Fannin county** uses 33 per cent "liver" or brown hematite ore. The old Aliculsie creek bloomary in **Murray county,** three miles from the Tennessee line and the old Armuchy creek bloomary ten miles south of Lafayette in **Walker county** are abandoned; but there still runs, on a branch of the Armuchy twelve miles east of Lafayette, the Clear creek charcoal furnace (H 251) on mixed fossil ore of V from 6 miles west and brown hematite from 8 miles east. The old Lookout creek bloomary in **Dade county** $3\frac{1}{2}$ miles south of Trenton was abandoned in 1851. All these run on brown hematites.

Georgia.

In **Cass county** the iron manufacture flourishes on primary mixed magnetic and brown hematite ores, the latter being outcrops of the former. The Crow bank, a vein of black oxide, half a mile east of the Allatoona creek furnace, and three miles east of the Mississippi and Atlantic railroad, yields 50 per cent pure iron. The Troy bank two miles west of the furnace is a richer but more expensive ore and therefore not at present used. Brown hematite 30 per cent ores from Red bank, a mile west of the furnace, and Cooper's bank, half a mile north of it are used to mix.—On Stamp creek are four furnaces Etowah, Pool, Union and Lewis's, the positions of which can be seen by reference to the Guide Nos. 246, 247, 248, 249. These use not only black oxide and brown hematite but red specular oxide ore. Etowah gets a 60 per cent 70 per cent ore 4 miles southwest. Pool and Union get a 60 per cent red oxide from the Big spring bank 3 miles west of the former and 2 miles northwest of the latter, half a mile southeast of which (nearer to Union) is a vein of 70 per cent black oxide. Peachtree bank 3 miles northwest and Wild bank (abandoned for the present) 3 miles north of Pool, yield red oxide ores. Lewis's furnace has its own 60 per cent "Big bank" 2 miles northwest of it, but uses also the 75 per cent ore from the Peachtree bank 2 miles west of it.—On Pettit's creek $2\frac{1}{2}$ miles north of the railway station the Cartersville furnace gets a 56 per cent ore from Foster's, Fullmore's and Giton's banks about 3 miles northeast, and Milner's $2\frac{1}{2}$ miles east.

Of the Cass county iron region in Georgia Mr. Hodge writes from New York, May 9, 1846 to Hon. John H. Lumpkin: The iron ore beds of Cass county, Georgia, are found in the Allatoona hills near the Etowah river, and may be traced in a northeast and southwest direction along these hills for about forty miles. Some of the beds are seen to continue almost without interruption for twelve miles. They come to the surface at intervals, and appear as solid rock ledges; and their position is also marked by piles of loose ore following the range of the beds, evidently derived from those lying *in place* beneath the surface. The quantity of ore in this region is incalculable. The loose pieces cover entirely the surface of some of the knolls and hills, and it seems that these are often wholly composed of the solid beds. On the top of one high hill which I examined was evidently the outcrop of an immense bed of the ore. The pieces, most of them weighing a few tons each, lay piled one upon another, forming a rocky mound along the ridge, that I could not cross on horseback. Every mass was *Hematite* of the very best quality; the thickness of the bed measured by pacing across this outcrop, was at least 150 feet, perhaps much more.

This variety of ore is the most common in this region. Though it yields a less percentage than the heavy magnetic ores, and the specular ores, it is preferred to these on account of the greater facility of smelting it, and the very superior quality of iron it makes. It is the same ore with that which makes the famous "Juniata" iron, the "Salisbury" iron and the "Stockbridge" iron, all which are the best adapted for heavy castings, and are well known for the soft and tough bar iron also into which they are refined. Several large pieces I brought with me of this Georgia hematite so nearly resemble the ore from the famous bed at West Stockbridge, that the most critical examination cannot detect any difference between them.

But this ore is in Georgia also associated with the other harder varieties, into which it seems to pass; and among these I found beds of a rich and very pure *specular* iron ore. This is the kind known as the Iron Mountain ore of Missouri, and is also found and extensively wrought at Rossie, St. Lawrence county New York.

Of the wonderful profusion of these ores, and of their richness I can unhesitatingly speak in the highest terms; and the best varieties and largest quantities I saw were among those within two or three miles of the Etowah river where it is crossed by the railroad. I have visited almost all the great iron ore deposits of the United States; have explored the beds of the Iron mountains of Missouri; but have never been so impressed by any exhibition of ore as by the mines of the Etowah district. They pass along within from one to five miles of the great Limestone formation of Cass county, so that this essential material for flux in the making of iron will everywhere be conveniently supplied. They are near a rich agricultural district, where provisions can be afforded at the cheapest rates; and yet they extend into the heart of the Allatoona chain of hills, where the air in the heat of summer is most salubrious, and the climate, like that of the tablelands of Mexico, perfectly healthy. Where the Etowah river has broken through these hills, the high ledges of rock still resist its progress, and a succession of falls over these furnish abundant water power for the most extensive works.

A large portion of this region is covered with a heavy growth of good, hard wood timber—the original unbroken forest. The best of charcoal was offered at the furnace in 1842 at 3½ cents per bushel.

The high rate of transportation to the coast, and the inconvenience of effecting

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repairs to machinery in a country where there are no large machine shops are the causes that have prevented these great resources from having been largely developed by the investment of northern capital. These obstacles were too serious to be encountered by private enterprise in a remote district, when the product of the mines was to look to a market already supplied from nearer sources.—In another report Mr. Hodge goes on :—

The iron mines of Georgia are in its northern counties among the spurs of the Alleghany mountains. The Blue Ridge comes into the State from North Carolina at its northeastern corner, and passes on towards Alabama in a southwest direction. The country bordering this ridge on the southern side is a mountainous region of primary rocks. Habersham and Lumpkin counties are made up of high parallel ridges and deep narrow valleys, lying for the most part in a northeast and southwest direction. The peculiar parallelism and straight course of the Alleghanies may be seen here as in the middle States; but their more broken character, the greater raggedness of their outline, the impetuous nature of their streams dashing over high ledges of rock, and the clearness of their waters testify to different geological formations than the stratified shales and sandstones of which they are composed in Pennsylvania. It is in these outliers of the main ridge of the Alleghanies that the metamorphic slates and quartz rock are found, which are productive in **gold ores**; and frequently in near proximity to these are deposits of **hematite iron ore** of extraordinary extent. In the gneiss also are found veins of **magnetic iron** ore of great purity, as at Cane creek, near Dahlonega; but to these little attention has been directed. Specimens of this ore, which I have seen at the mint at Dahlonega were very rich and remarkable for their strong magnetic power. **Specular ores too,** like those of the Iron mountain in Missouri, are found in considerable quantity in the vicinity of some of the hematite beds, which I shall allude to again.

The three furnaces in this State are situated in this region and are supplied with hematite ores only. The first is in Habersham county three miles below Clarksville. The ores are said to be abundant, and the expenses of manufacture very low. Localities of the same are of frequent occurrence from this point down the course of the Chattahoochie river; but none of them are turned to any account.

Another range of them of much greater consequence is found

in the Allatoona hills along the Etowah river in Cass and Cherokee counties. And as a railroad already passes through this iron district, it gives to it an importance that will lead me to describe with some minuteness of detail its resources.

The northwestern counties of Georgia, which include the territory purchased of the Cherokee Indians, was divided when apportioned among the inhabitants of the State in 1832 and 1833, into four *sections;* these were subdivided into *districts* of nine miles square each, and the districts either into 40 acre or 160 acre lots. After this plan the country was surveyed, mapped, and each lot numbered. Afterwards the counties were formed. Plate — is a map of Cherokee county and a part of Cass county, the former lying in the second section, and the latter in the third. The districts are represented and numbered with large figures; the smaller figures occasionally noticed are the numbers of particular lots in the districts.

The Allatoona hills lie mostly in the southeastern corner of Cass county. They extend in a northeasterly direction towards the Blue Ridge, of which they are probably the continuation. The Etowah river, a broad shallow stream, passes in a westerly direction through the southern part of Cass county, breaking obliquely through these hills. Obstructed in its course, it falls over ledges of rock producing water-power, which has been improved by dams between the mountains from 300 to 400 feet long. The railroad from Augusta, through the Cherokee county into Tennessee, crosses the Etowah in the midst of these hills. In its progress through the northern part of Cobb county, it passes through mica slate, hornblende rock and quartz rock which dip steeply towards the east; the surface is rolling, but not rough. But as it approaches the Allatoona hills, the country is much broken; high embankments across deep hollows are frequent and cuts through the solid rock, in one instance to the depth of 90 feet and 300 or 400 yards in length, are found necessary for the road. These cuts are in talcose slate, which lies inclined south of east at an angle of about 75°. Quartz rock, hornblende slate and greenstone alternate with the talcose slate; and near the greenstone gold is extracted from the quartz veins. Limestone is found in beds in these rocks, and near the limestone, iron ore.

Beyond the Allatoona hills to the west and north is an exten-

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sive limestone country commencing about 4 miles from the Etowah river. Nearly the whole of Cass county is formed of this rock and it spreads out into Floyd and Murray counties. From its position adjacent to the metamorphic rocks of the Allatoona hills and bordering on the other side the newer secondary strata, which over the line in Tennessee reach up to the coal formation, this is probably no other than the Trenton or Birdseye limestone of the New York groups. From what information I could obtain it would seem that the eastern boundary line of this formation passes nearly north through the western parts of Cherokee and Gilmer counties into Tennessee.

The iron ores are found on both sides the Etowah river. To the southwest they extend into Paulding county and in the other direction through Cherokee county, the furthest place on which I have observed them being between Sharp mountain creek and Long Swamp creek in the northeastern corner of this county. So far as explored, their range is found to be full forty miles, and their course about northeast and southwest.

The first locality I shall describe is that of *Pumpkin-vine* or *Town creek* in the southeastern corner of Cass county. For a mile or two before this stream enters the Etowah, it has left the high hills of the Allatoona range, and flows through rich bottom lands, which widen out about its mouth into very broad and fertile meadows. Here, along the Etowah, are extensive plantations which produce large supplies of corn and grain. Up the creek, almost into the midst of the mountains, the stream is skirted on one side or the other with similar bottom lands, but covered when I saw them in 1842 with a heavy growth of poplar, beech, oak, walnut, chestnut, ash, hickory etc. all of the first growth, and much of it very large timber. The width of these bottoms three miles above the mouth of the creek is three-quarters of a mile. On each side, the hills rise to the height of from 200 to 400 feet. They are composed of talcose slate, hornblende slate, quartz rock and some limestone and iron ore. Their sides and summits, though covered with wood, are stony and barren. The slates with quartz veins, some of them auriferous, occur on the south side the creek; on the north side the hills are more generally quartz rock with beds of silicious limestone. Near this limestone are found the beds of hematite.

They crop out in the sides of the hill next the creek and are seen in large deposits of unknown extent. The most important localities are on the 40-acre lots numbered 1038 and 1040 near the canal. On the former the ore and limestone are found near together and more convenient to the proposed site of a blast furnace at the termination of the canal, which was dug by Mr. Neleigh, the proprietor of this place, to give good water power.

On 1040 is a knoll around which the canal winds, which contains a very large supply of the very best quality of hematite. A trench sunk below the soil laid bare a ledge of this ore its whole length of about 30 yards without affording any indication of its limits. The ore much resembles the best of the West Stockbridge ore in Massachusetts. It has the same loose shelly structure covered with reddish-yellow rust on one side, the compact chocolate and black pure ore within, and on the other side it is covered with projecting stalactites of ore. In quantity, quality and convenience of ore this locality seems to leave nothing to be desired, and it is, besides, within two miles of the railroad.

The limestone when burned produces a pretty white and strong lime; it is evidently silicious, and is said to have made hydraulic cement, having been used by the engineers on the railroad for this purpose. Near the ledges of it the quartz rock appears flinty and ferruginous; rotten veins traverse it containing sulphate of barytes, often well crystallized. On lot No. 970, near the railroad, is a high hill of quartz rock, on which is found a close-grained peroxide of iron of apparently great purity. It will probably prove an ore to work with the hematites. The quantity is evidently great, but no attempts have been made to ascertain it. This is the ore before referred to as resembling the Iron mountain ore of Missouri.

The water power of Pumpkin-vine creek cannot be depended upon for extensive works. By means of the canal, which is nearly a mile long, a fall is obtained of about 14 feet; and with this head there is enough water for one furnace almost the whole of the year. Higher up the stream are falls of more certain dependence, but not in so convenient a situation to the ore. Wood for charcoal can be obtained in the bottoms and on the hills in large quantities for many years to come at very low prices.

Georgia.

The situation is healthy, except where the bottoms are overflowed or low lands are cleared and the timber left to rot upon them. Among the hills or by the swifter running streams no region in the United States is more salubrious or enjoys a more delightful climate. Its elevation above the sea saves it from the excessive summer heats of the lower parts of the State, and its southern latitude gives it temperate and pleasant winters. These advantages together with the fertility of a large portion of the country have led to it a considerable population, who have built up many thriving towns and established manufactories of various sorts, so that the country more resembles New England than any portion of the southern agricultural States.

The railroad passing through this region is a branch of the Georgia railroad, uniting with it at Atalanta. The whole distance through to Augusta is about 200 miles. In the other direction the road passes into Tennessee by two branches. By the western one to Chattanooga access is had to the bituminous coal field, which is about 80 miles from the Etowah. If wood were likely to be scarce, this might be considered of some consequence to the iron mines. But for a long time abundant supplies of charcoal may be depended upon; and it is besides very questionable whether the bituminous coal of these southern fields is not too highly charged with bitumen to be economically used in the manufacture of iron.

The deposits of iron ore approach the river on its northern side about two miles above the railroad bridge. Here the mountains come down to the water's edge, and the only paths back from the river are up the narrow valleys of the runs. In these the rock of the mountain is exposed to view. It is a hard compact silicious rock, lying in strata of different thicknesses, sometimes the layers being very thin and at others heavy blocks. They dip to the south of east. Associated with this rock are the beds of hematite; they crop out like any other ledge, and their extent cannot be estimated. These ledges near their contact with the quartz rock are more or less mixed with it and much of the ore is then too silicious for use. But vast quantities are found covering the sides and top of one of the mountains, extending more than a mile, that are of greater purity, and would probably work well in the blast furnace. The locality is very

convenient to the rapids on the river. A bed of limestone is said to occur near the ore and the river in the quartz rock. Veins of sulphate of barytes are common. The water power here is very great and is never known to fail. At this locality is found the singular flexible quartz or sandstone noticed also in South Carolina. Strips of it or layers are found in the common quartz rock, which on being removed bend in the hand, as though they were breaking apart. It is found also with the same associates of iron ores and gold as well as of diamonds at the Peak of Itacolumi in Brazil; and M. Eschwege has proposed for it the name of itacolumite.

In the vicinity of the furnaces the rock is a coarse mixture, like a breccia, of quartz and feldspar. It is a rough looking rock and cropping out everywhere gives a barren aspect to the hills. Beyond the furnaces to the northeast the ore is found in even greater quantities than before noticed. Upon a high knob eight miles from the river is a greater show of it than I have seen at the famous Iron mountain in Missouri. The hill, which is nearly as high as the "Pilot Knob" near the Iron mountain, and which may well be called the *Iron knob*, has upon its summit the outcrop of a bed of hematite fifty paces across, the rocks of ore piled upon each other, forming so rough a path that it cannot be crossed on horseback. Below it the sides of the hill are covered almost wholly with ore. The bed is interstratified with the coarse brecciated feldspar and quartz, dipping 75° or 80° east by south. The rock beneath it is of much finer texture than that above. Towards the river the bed may be traced a mile without losing it beneath the soil; and in the other direction I was told it had been followed without interruption two miles further. It probably goes to the river, being on the range of beds there, which would make its length no less than ten miles. The quality of the ore varies at different points along its range, some of it being coarse, and some the very best quality of brown hematite. At least two other beds have been found near it, which pursue a parallel course with it. The ore in these varies in quality, but everywhere the beds are of enormous thickness. Manganese ore is found occasionally under the iron ore, but I cannot speak as to its purity. Beds of limestone are often close to the hematite beds. Without then being aware of the almost universal proximity of this rock to the ore in the

northern States I find noted the fact of its occurring "very near the ore, of compact structure and white and blue colors. It is probably over the ore but this is not ascertained. It does not always accompany it, as for instance in the Iron knob."

Missouri.

I again met with beds of hematite on what proved to be the continuation of this range about the corner of where districts 3, 4, 13 and 14 meet, near Sharp mountain creek. The quantity here too upon Sharp mountain, within six miles of the river, is enormous, and the quality of much of it is good botryoidal and stalactical hematite. I remarked a change in the character of the quartz rock as it approaches these beds of ore. From a milky white color, it becomes glassy and of red and yellow hues; it then contains lumps and seams of iron ore. The sand on the hillsides and in the road abounds with ferruginous particles. Some of it is good black sand for desk use. Mica slate is seen among the loose stones, and the scales of mica shine in the sands. Rich grass grows abundantly in the woods.

One of the largest beds of ore is a mile west of Sharp mountain creek, four miles above its mouth. Falls or "Shoals" on the creek are within a mile and a half of this bed, and close to another deposit. On lot 338, 4th district, is a hill covered with hematite, apparently 100 yards across, and easily traced more than a mile in a northeast direction, between Sharp mountain creek and Long Swamp creek. Other parallel beds occur near by. All these are north of the limits of the map of this iron ore district. Within a few miles of these localities, on the head branches of Long Swamp creek, are beds of white marble.

The magnetic and specular ores of Missouri have become matters of celebrity and subjects of considerable discussion. They rise with the Lower Silurian and Huronian rocks in a geological island, a hundred miles southwest of St. Louis, from beneath the surrounding Silurian, Devonian and Carboniferous strata, and are separated therefore geographically from the primaries of the Atlantic seaboard, Canada and the Lake Superior region by continental stretches of these later formations, under which however of course they might be found, at the depth of from one to five miles beneath the surface of all the western States. This island is also separated from the primaries of the

Black hills and Rocky mountains by immense distances, covered not only by the same but by still later formations, Trias? Lias, Cretaceous and Tertiary. The Missouri primary ores will therefore always be a special depot of wealth under the protection of the politics and in the hands of the industry and skill of that State, fearing no rivalry, asking no tariff, but steadily concentrating about itself the iron manufacturers of an empire west of the Mississippi river.

Pilot Knob, against the north base of which two furnaces at present stand and from which they obtain their ore, is "581 feet high, covers an area of 360 square acres, and contains at least 14,000,000 tons of silicious specular iron ore (see Swallow's Geol. Report), of steel grey fracture," and according to Prof. F. A. Kayser containing protoxide of iron 84.85, silica 10.41, alumina 5.64. It differs somewhat in appearance from that at Iron mountain, and unlike the latter exhibits a series of well-marked strata divided by thin layers of slate. The ore is mined at a point about 400 feet above the furnaces and is let down to the latter in cars, over an inclined railway, the upper end of which rests upon a solid floor of ore, and from this upward can be distinctly traced the out-crops of five massive strata of ore forming, upon the northeast and east sides of the knob, successive series of picturesque weather-worn pinnacles. These plates of ore one above another decrease of course in area as one ascends, the last forming a small, irregular, turreted mass of iron upon the summit of the hill, the whole sides of which are covered with a thrifty growth of trees, flowers, moss and ferns.[9] There can be no doubt of the sedimentary origin of these valuable deposits nor of their relationship to the same azoic or Huronian System to which belong the ores of North Carolina, the Adirondac regions of New York, and Lake Superior. It is a great mistake to suppose the Iron mountain of Missouri a conical peak with steep sides covered with blocks of nearly pure iron (as it has been described by inaccurate observers), and perhaps consisting entirely of such loose blocks throughout as some ignorant speculators have suggested. On the contrary it is merely a gently sloping table slowly rising from the level of the furnaces to an elevation no greater than 150 feet, and partially divided into two.

[9] J. Lesley, jun. 1857. The Pilot Knob differs considerably (says Whitney) from the Iron mountain in character. It is much higher, by estimate 650 feet above its base, and is mainly composed of a dark silicious rock, distinctly bedded, and dipping to the south at an angle of 25° or 30°. For about two-thirds of the distance to the summit, the quartz rock predominates; above that the iron is found in heavy beds alternating with silicious matter. Some of these beds are very wide, and made up of nearly pure micaceous and specular ore. The richest ores show a very evident slaty structure, differing in this respect entirely from those of the Iron mountain, which are compact and without any noticeable cleavage. The summit of the Pilot Knob is ragged and bare, except where covered by moss, and forms a conspicuous object in the distance; hence the name. The cost of making blooms was stated to me as $30 per ton. The ore cost 20 cents a ton delivered at the roasting-heap; that of Shepherd's mountain cost 55 cents. The woodland is owned by the company; 35 cents a cord is paid for cutting, and charged to the coalers, who are paid from 2¾ to 3 cents a bushel for the coal delivered at the furnace. There are about 300 persons employed at this place and at the Iron mountain. The abundance and purity of the ore in the vicinity can hardly be surpassed; and it will eventually be carried in large quantities to the Mississippi and mixed with other ores to be smelted by hard coal. At present, charcoal is abundant and cheap.

Missouri.

This gradual rise, the steep outcrop escarpment under its highest point facing the syenite and porphyry hills beyond, and the often thickly scattered blocks which cover the slope, concur to show that it is a sedimentary stratum like the layers of the Pilot Knob, of a definite and certainly extraordinary depth or thickness, and perhaps even underlaid by a series of similar strata.

Iron Mountain in Dr. Litton's Report to Prof. Swallow, State Geologist (see Geological Report, 1856, part 1, p. 155), is called 228 feet high and 500 acres in extent, containing 230 millions of tons of specular ore of *igneous* origin, *enlarging downwards*, every foot in depth of which will yield 3 millions of tons. No part of this calculation can be relied on as approaching the truth, as it starts with a supposition that the whole 228 feet of mountain (or more properly *hill*) is solid ore, and concludes with a supposition that the ore is a volcanic ejection and increases in size towards the centre of the earth. Whereas the ore is undoubtedly a stratum nearly horizontal and merely plating or protecting the hill. The top of the Iron mountain is 900 feet above St. Louis, and about 260 above the surrounding country, and its area with some smaller deposits around it about 500 acres. The ore is a micaceous oxide and when fractured has a bright metallic appearance and seems to be very uniform in quality and richness whether in place or detached. It yields from 55 to 60 per cent in the blast furnace, is easily smelted, making red-short but very superior iron. The surface is literally paved with huge boulders of ore, and in the absence of these with disintegrated ore. Successive layers of pebbles of ore have been removed from small plots here and there, but no attempt has been made to open a quarry or mine in the main body. On one of the adjoining spurs and near the upper bank of the furnaces a breast of 40 feet has been opened for their use, presenting a massive front untraversed by a seam of either earth or rock, and with but a few inches of debris covering the surface of it. On the lower bank or at the level of the casting-houses an artesian well has gone down 180 (one hundred and eighty) feet in "solid ore." Pilot Knob six miles further south and 400 feet high above the level of the surrounding country shows no ore on its base and sides but large boulders are piled up at the top tapering to a summit of a couple of acres in area. This ore is let down by a series of inclined planes, of different grades in the same line, to the furnaces on the level below. It is not as pure as that of the Iron mountain and does not yield as well in the blast furnaces and is more refractory. Nevertheless, I question whether there is a deposit of iron ore on the globe embraced within equal limits that contains as much mineral of the kind. Situated within 50 miles of the Mississippi and not much further from the coal of southern Illinois, it requires but little forecast to estimate the vast proportions that the iron trade will assume in that section of the country in a few years.[1] The mode of occurrence (says Whitney) of the eruptive ores in the azoic has already been described, and the Iron mountain alluded to as a remarkable instance of a mass of this character. It is a flattened dome-shaped elevation, of about 200 feet above its base, and forms the western extremity of a ridge of reddish feldspathic porphyry, which rises one or two hundred feet higher than the knob of iron ore, and stretches to the east for a mile or two. The surface of the Iron mountain is entirely covered with loose pieces of ore, which become more and more conspicuous toward the summit, on account of the small quantity of soil and vegetation covering them, as well as from the fact that the masses of ore themselves grow larger and more angular. The summit is covered with moss-grown blocks, some of which are many tons in

[1] Charles B. Forney of Lebanon, Pennsylvania, August, 1858.

weight, piled together in the greatest confusion. Nowhere about the mountain can the rock or ore be seen *in place.* On the west end of the hill a considerable excavation has been made for the purpose of getting out the ore. A vertical cut was carried to the depth of 8 feet, and a shaft sunk 7 feet further; at the bottom, a bed of red clay, destitute of boulders, was struck and penetrated for one foot only, without reaching the solid ore. It appears, therefore, that the bed of loose masses covering the side of the mountain is at this point at least 15 feet thick; it is here made up entirely of small, somewhat rounded pieces of ore, packed together without any other substance than a little bright-red ferruginous clay between them. The ore requires no selecting or washing, as there are no foreign boulders or stones mixed with it. Flux is abundant at a distance of half a mile, costing 25 cents at the tunnel-head per ton of iron produced. Charcoal, the only fuel used, costs 3½ cents a bushel; the company owning the woodland, and paying that sum for burning and hauling to the furnace. About 110 bushels of coal are required to make one ton of iron. The ore costs 80 cents a ton, mined, roasted, broken up, and delivered at the tunnel-head.[2] All three furnaces at the Iron mountain use the same ore and blow with a strong blast. The surface ore is selected for making malleable iron and castings, and the mined ore for cold-blast mill and hot-blast foundry iron. The variety of analyses of these ores is remarkable. Prof. Collum of Sainte Etienne in France, calls it a 71 per cent ore. Two other analyses from the same laboratory are as follows:—

	Iron Mountain Ore.		Pilot Knob Ore.	
Iron	65.0	=100.4	66.0	=100
Oxygen	29.0		26.0	
Silica	3.5		5.0	
Alumina	2.9		3.0	

respecting which analyses F. A. Kayser remarks that the excess of oxygen (27.86 oxygen being the maximum equivalent of 65 iron) proves that "silica" and "alumina" should read silicon and aluminum, and the analyses themselves as follows:—

Perox. iron	46.69	=100.39	84.85	=100.90
Protox. iron	40.97		..	
Silica	7.28		10.41	
Alumina	5.45		5.64	

Dr. Litton (Swallow's Report p. 78) gives peroxide iron 99.33, silica 0.66=Iron 69.55.[3] Iron mountain ore, from Missouri, afforded E. Harrison Fe 68.95, O 27.00, Sand, etc. 3.07 with a trace of manganese=99.02 the composition of hematite $\bar{\mathrm{F}}\mathrm{e}$.[4] Other specular ore beds are noticed in the same report as exposed near the Pilot Knob, as for example the Bogy or Buford ore bed, Town. 33 R. 3 east-northeast ¼, Sec. 24—Big Bogy mountain southeast ¼, Sec. 13; and Russel mountain, east ½, Sec 3.

Shepherd Mountain ore, specular and magnetic (the specular greatly predominating with 2 per cent of silex and alumina and no other foreign ingredient, is described as occurring in vertical veins from 1 to 14 feet thick, cutting through porphyry in various directions. (Letton's Rep. p. 81.) So in Town. 33, R north ½, Sec. 2 are several veins of specular ore nearly vertical, the largest one foot thick

[2] Metallic Wealth, p. 480. [3] Proc. Boston S. N. H. 1858, p. 295.
[4] Bulletin Amer. Iron Assoc., 1858.

cutting through porphyry in a nearly meridional direction. Here an old furnace was once in operation. **Missouri.**

In Phelps county the Maramec furnaces, situated south of the southwest branch of the Pacific railroad and fifty miles south of Hermann on the Missouri river, use a peculiar magnetic ore, mined from a hill lying one-third of a mile west. "The furnace is only run enough to supply the forge with metal, as the blooms must be hauled 60 miles to Grey's Summit (Pacific railroad) station. This fall, however, there will be 20 miles of the South Branch railroad in running order which will cut off that much, and orders have been issued to complete the road to our station, 6 miles from here, as fast as possible."[5] This ore is pronounced in the late report of Prof. Swallow to the Southwest Branch Railroad Company page 30[6] the oldest known and perhaps most valuable deposit in this county (*Crawford*) situated half a mile from the Maramec on the west side; opened as early as 1826 by Massey and James; furnace completed 1829 and operating at intervals until now; ore rich compact specular, wrought by the Messrs. James, in large rounded or angular masses (inexhaustible) which when broken exhibit cavities filled with small, beautiful, iridescent fibrous crystals of iron, and sometimes transparent crystals of quartz. In some parts this ore is embedded in soft purplish soapy hematite sold largely for paint.[7] The sandstone in the neighborhood contains masses of iron pyrites.

In Crawford county Dr. Shumard reports *specular oxide* with brown hematite and sulphuret of iron. The two first occur together in SE of NE qr. sec. 5 T 37 R 4 W, thickly strewn over the surface and probably existing in workable quantities. At Bleeding Hill (according to Mr. Engelmann) near the eastern line of the county just south of Maramec river, is a rich deposit of *specular oxide* of excellent quality, two shafts having been sunk through thirty-seven feet of red clay and comminuted chert, encountering a 4 foot bed of soft purple iron ore, greasy, like the paint ore of the Maramec iron works.—In NW of sec. 13 T 37 R 7, *specular ore* abounds with pseudomorphous crystals of pyrites; and in SE of SW qr. sec. 32 T 35 R 5,—sec. 4 T 37 R 3—and other places.—In sec. 32 T 37 R 8 Engelmann exa-

[5] Wm. James, Corr. to Amer. Iron Assoc. May 8, 1858. [6] St. Louis, 1859.

[7] Probably magnesian and an additional evidence of the derivation of the specular iron ores from the dissolution of the rocks in places.

mined an extensive deposit of *specular ore* like the Maramec bed.—In NW qr. sec. 27 T 36 R 7, large masses of *specular* and *brown iron ore* abound on the surface and much good argillaceous red hematite has been taken from a shaft 15 feet deep.[8]

In Pulaski county a large deposit of *specular* ore, like the Maramec, was examined by Engelmann in sec. 31 T 37 R 12. A large deposit of *brown hematite* in NE qr. sec. 30 T 36 R 11 occurs in cherty beds of second and third magnesian limestones (Lower Silurian No. II) and on Bee Branch T 37 R 10—Sulphuret and brown hematite in sec. 9 T 38 R 13.[9]

In La Clede county fragments of *specular ore* and brown hematite are observed in small quantities in many places.[1]

In **Wisconsin** Primaries begin to appear (going north) on the Upper Mississippi and Black and other affluent rivers, but are concealed over the upland by the Lower Silurian, etc.

On the east bank of Black river near the Falls, 4 miles from flatboat navigation to the Mississippi and on the line of the Land Grant Branch railroad, is a furnace built by a German company, who have made but little iron on account of the failure of the (Potsdam, Lower Silurian No. I) sandstone hearths, as well as one got from Amherst, Ohio; ore magnetic and red oxide, two tons making one of iron; cost of ore \$1 50 delivered; it needs 20 per cent of lime; pine wood abundant, hard wood in streaks. The quantity estimated in sight is 15 millions of tons on Darrow & Curtz' land west bank and 28 millions on Iron Company and Telden's mound lands east bank.

Analysis by Dr. C. T. Jackson:—		Red Oxide.	Specular and Magnetic.
	Peroxide Iron	67.50 (=47.27 metal)	64.00 (=44.82 metal)
	Silica	26.75	36.00
	Ox. Mang.	3.65	
	Water	1.50	

The ore occurs in gneissoid (Huronian) rocks overlain nonconformably by horizontal Potsdam sandstone with lingulæ, footprints and trilobites; near granite, syenite, trap, mica slates and chloritic slates, up through which last two the great red ore masses rise from 6 to 40 feet wide; an exposure of black oxide highly magnetic 45 feet high dipping 75° southeast is seen lower down. (See full account on p. 28 of Daniels' Geological Report.)

[8] St. Louis, 1859. [9] Same report. [1] Same report.

Wisconsin.

Nothing can be more satisfactory than the proximity of these same ores and rocks here, in northern New York and in North Carolina; ncr can a more satisfactory demonstration be thought of for their sedimentary origin during a single geological epoch.

In Northern Wisconsin, the magnetic-iron beds of the Penokie Range are described by Col. Charles Whittlesey, in Owens' Report of Iowa, 1852, page 144 to 147 as follows:

The most easterly appearance of magnetic iron which I observed was in fissile black slate about four miles west of the Montreal Trail, along which the Section No. 4, W, is made. The bed lies back of the trappose range, about sixteen miles from the Lake, in a protrusion of metamorphic slates, the argillaceous portions merely tinged with iron. About four miles along the strike of the beds, southwest by west, the bed was seen by Mr. Randall, in 1848, in the Fourth Principal Meridian in Township 44° north, eighteen miles from the Lake. From thence I and my assistant, Mr. Beesly, an active woodsman, and faithful and acute observer, traced it at moderate intervals, along the uplift, to the west end of "Lac des Anglais," or about fifteen miles, to where the range terminates.[2] Here the metamorphic slates, that first show themselves between the Montreal river and the Montreal Trail, on the east, sink beneath the level of the country, and are replaced by syenitic rocks. By examining the Sections Nos. 1, 2, 3, and 4, W, attached to this Report, the position of the iron-bearing rocks will be found to be the same in each; and the details of the rocky beds above and below the iron are also the same, so that we may with confidence pronounce it to be a continuous bed from the meridian westward to Lac des Anglais. Its thickness, richness and value vary very much; but we found it more or less developed whenever we crossed the range, and could get a view of the rock.

The geological relations of the iron-bearing strata are exhibited in the two following sections, the first taken near the trail that passes over the Pewabic Range, between the Forks of the Tyler branch of Bad river; the second, south of Lac des Anglais.

d, *d*. Drift.
c. Slaty magnetic iron, fifty feet.
b. Compact and slaty quartz.
a. Talcose slate.

d, *d*. Drift.
c. Iron-bed twenty-five to sixty feet.
b. Quartz, thirty feet.
a. Hornblende and slaty quartz.

On the Pewabic Range, the strike of the beds is east by north; the dip north by west, 80° to 85°. The beds of quartz are of great thickness—two hundred to two

[2] There being but one surveyed line in the Bad river country, the distances are of course by approximate estimation.

hundred and fifty feet. Near the junction of the quartz and talcose slate, the latter assumes the aspect of novaculite. The iron-bed is schistose in its structure, and is composed of magnetic oxide, sometimes alternating with beds of quartz. The total thickness of the talcose slate is not seen; it must be very thick, and is traversed by numerous veins of quartz. Its dip and strike are variable.

The bed of magnetic iron ore south of Lac des Anglais is of extraordinary thickness—twenty-five to sixty feet. The dip here is northeasterly, and the layers variable in thickness that alternate with the quartz, which latter repose upon hornblendic slate, running downwards into talcose slate. Here, as well as on the Pewabic Range, the dip and strike of the beds are variable. The metamorphic strata are very much disturbed throughout this range; but agree in having the mural faces of the uplifts to the south and southeast, and the dip northerly and northwesterly at various angles of from 5° to 60°. The effect of this irregular action is to make detached ridges and crests, sometimes two, three and five miles long, thrown up at different elevations and inclinations.

Sometimes the iron stratum is composed of laminæ of quartz and magnetic oxide, alternating, as at the crossing of the trail between the forks of the Tyler Branch of Bad river; also south of Lac des Anglais. The proportion of iron and quartz is very variable, but the separation of them by mechanical means would in general not be difficult. The bands of ore vary from mere thin laminæ to a thickness of twelve and even eighteen inches, presenting sometimes a black surface, contrasting with the white and grey color of the quartz, and sometimes a bright metallic grey color. The thickness of the metalliferous portion varies in the extreme from five and ten feet up to fifty and seventy feet; and at the passage of the main portion of Bad river through the range reaches two hundred and fifty feet. These exposed faces frequently extend beneath the surface, where, of course, no estimate can be formed of their entire thickness. There are many places in the mountain, west of Bad River, which present more than fifty feet of quartz and iron, in about equal proportions. In the wild and deep ravines where the Bad river breaks through the range, there is a cliff of slaty ore, most of which comes out in thin, oblique prisms, with well-defined angles and straight edges, probably three hundred feet thick, including what is covered by the talus or fallen portions. I estimate more than one-half of this face to be ore; and, in places, the beds are from ten to twelve feet in thickness, with very little intermixture of quartz. There are portions of it not slaty, but thick-bedded. The dip of the laminæ is mostly north and by east, 80° and 85°. The convulsions that have occurred at this point have thrown a part of the range beyond the rest of it, to the northward, so that in crossing the river, and passing along the mountain to the eastward, for several miles, the ferruginous bed, as well as many of the associate strata, were not visible above the general surface of the ground. It should, however be borne in mind, that the whole region is not only covered so thickly with timber that no distant views can be had without climbing trees, but the drift often conceals the rocks, over a large portion even of the elevated ridges; in addition, the rocks themselves, previous to the era of the drift, have been the sport of giant forces, which tossed and tilted them about at various angles and elevations, realizing the fable of Atlas.

Where the west branch of Tyler's Fork crosses the chain, Mr. Beesly found the southerly face of the uplifts well charged with a rich, heavy ore, showing thirty, fifty, and seventy feet, with iron predominating over quartz.

All the specimens we saw were of the black magnetic oxide, without any of the red. The surface was not affected by weather, the angles of the rectangular slaty

Wisconsin.

pieces and blocks that have fallen from the cliffs in great numbers, were entire, and not rounded by time. I infer that the mineral contains in its composition a notable proportion of silex. The productive yield of such an ore can only be determined by trial in properly constructed furnaces, but judging of our specimens by weight, they will afford fifty to sixty per cent of metal. The analysis of one specimen (No. 7) by Dr. Owen, yielded over sixty-six per cent.[3] For present use a supply of ore may be obtained from the rubbish at the foot of the uplifts, in blocks and pieces already detached from the cliff and the accompanying quartz. Where it is not dislodged, it will be necessary to break the whole, and then assort it. There are cases where numerous particles of the oxides, both red and black (the protoxide and the peroxide), are disseminated through the quartz-rock above and below the regular beds. This might be separated by bruising and stamping—a process which the whole must undergo, in order to be profitably wrought in the forges. There is no limestone yet known in the region to be used as a flux; but there is an abundance of timber and water-power. There are certain proportions of iron and silex, and of silex and magnesia, that are easily fused. If the silex of this ore is not so excessive as to make it refractory, or if in practice that difficulty can be remedied by the use of magnesian slates, which are abundant, these mines may be wrought hereafter at a profit, and rival the works of Northern Europe. The magnetic ores of the northern part of the State of New York, that have produced iron famous for its strength, are also silicious. The magnetic iron ore is freed of a portion of its silex, at little expense, after being bruised, by the application of magnets acting on a large scale upon the magnetic particles. The part which enters chemically into the ore forming a silicate, is not wholly cleared by working, but gives a very fine-grained metal, that is peculiarly good for steel. The famous Swedish iron is from beds of magnetic ore embraced in hornblende rocks, doubtless metamorphic, and analogous to the Bad river rocks. The extensive mines or rather mountains of iron ore in Michigan, described by Houghton, Burt, Jackson, Foster, and Whitney, are also magnetic, and associated with metamorphic slates. These ores are, in some cases, more inclined to the peroxide than the Bad river beds; but specimens from the two regions are often so similar that no one would be able to separate them by the texture, color, or weight. The geological associations are precisely alike. In Michigan, as in Wisconsin, the mountains composed of tilted magnesian, hornblende, and silicious slates, inclose beds of ore. There, as here, on each side of the metamorphic range, are igneous rocks, of various ages and composition, quartzose, granitic, syenitic, and trappose. The ores of that region have attracted attention, and one establishment for making blooms direct from the ore, has been in operation more than a year. The iron is remarkable for its solidity and toughness, keeping its place better than Swedish, and no more brittle. It possesses the quality of being worked into fine cold-drawn wire, and has been sought after by an establishment for manufacturing wire in Massachusetts. The blooms brought from Lake Superior

[3] The analysis of Specimen No. 7, from the slaty beds of the mountain, south of Lac des Anglais, gave as follows: Peroxide 51.5, Protoxide 27.1, mixed 78.6, = 56.3 iron; Silica 20.8, Magnesia 00.6, Alkali 0.02, Fluoric acid, a trace. The excess arises from an absorption of oxygen by the protoxide. The analysis is subject to revision, if time permits, in this particular, but the result in pure iron cannot be materially changed. This specimen is apparently 10 or 20 per cent below the richest pieces brought from the Range, and is above some of the poorer slaty specimens.

to the Pittsburg market are, however, represented as being inclined to "red short," that is liable to crack under the roller or hammer, at about a red heat.

The position of the best exposures of ore which I saw is such as to require from eighteen to twenty-eight miles of transportation to reach the Lake. The nearest natural harbor is in Chegwomigon Bay, about twenty-five miles from the central part of the Penokie Range. At Montreal river, which is the nearest part of the coast, and from its mouth to the mouth of Bad river, there is no place where an artificial harbor can be made. At Bad river, there will be a good harbor when the sand bar at the mouth is removed and kept clear by the construction of piers.

In **Michigan** the Lake Superior Marquette beds begin near the north line of Appleton and on the north side of the Menomonee river and continue to show themselves at intervals in a northerly direction for fifty miles and with an equal width east and west. Like the beds of northern New York they are chiefly magnetic and specular and present cliffs and ridges of nearly pure metal. No less than fourteen large beds have been found by the government surveyors in running out the township lines and seven times as many are computed to exist. One cliff of solid ore is 113 feet high and the ridge a mile and a half long. Whether or not this wonderful iron region stretches across the river into Wisconsin is not yet known through government surveys. Slate rocks crop out upon the river rapids; but in one place called the Iron Cascade the river falls twenty feet over a bed of magnetic iron in the midst of a forest of hard maple, beech and other good charcoal woods. The veins of iron extend across the Montreal river into the Penokie mountains which skirt the Lake Superior shore.

Jacob's beds near the northern line of the 48 mile railroad reservation, on the Michigan side of the Menomonee and two miles from the river are of specular ore in talc and clay slate, fine grained, blue-black, giving a red streak. It can be traced a mile and a half along the shore of a small lake and is exposed in places for a width of 100 feet; the ridge is about that high and shows a slaty ore for 40 rods upon its summit bearing nearly east and west. Four miles east of it are ledges of pale blue mottled marble.

Foster describes the cliff of ore on the Peshakame 113 feet in perpendicular height without an accessible break for more than a quarter of a mile. At the top the mass was comparatively pure for 40 feet; behind was a stratum 15 feet thick

Lake Superior.

of quartz conglomerate and rounded grains of iron; then followed specular iron again for 100 feet when soil and trees prevented further view.[4]

The distinguished professor of Geology in the Paris School of Mines, Rivot, in his notice of Lake Superior[5] says that iron ores form in many places considerable masses connected with amphibole schists ranging like most of the rocks of this region east and west. [The lake itself lies east and west and the outcrops of the Silurian rocks take the same general course from New York to Minnesota.] They vary much in value. Some thick beds of oligist mixed with a little oxydulé contain but 2 or 3 per cent of the silicious amphibole while, close by, the silex will be so abundant in the ore as to prevent it from yielding more than 30 to 45 per cent of iron in the furnace. At the older mines (Jackson) there are trap rocks, talcose schists and amphibole schists, showing their primitive stratification; while to the north and south are massive exposures of quartz conglomerates, made up of pebbles of all sorts, even of iron ores, embedded in a ferruginous paste; so that the iron itself is evidently of a very ancient date.* The mines lie inland, but so high (300–400 feet) above the lake, that the ores can readily be brought to the shore. These ores west of Marquette have been wrought for many years but not actively until the spring of 1855. A railway now brings the ore to Marquette for exportation to the furnaces and rolling mills near Detroit and to rolling mills at Pittsburg and elsewhere on the Ohio river waters, to be employed in lining and flooring the puddling furnaces, to protect the walls and floor of brick from the action of the puddled pig metal. No doubt high furnaces, forges and steel works will spring up at Marquette.

The gangue-rock is a mixture of quartz and a silicate of iron, alumina and lime. The iron exists in nearly all the specimens as an anhydrous peroxide (fer oligiste); three, containing a little protoxide; one, a quantity of hydrated oxide. No traces of sulphur, phosphorus or arsenic were discernible; the silica is therefore the only enemy in the furnace.

[4] Report. Quoted also in Third Ann. Rept. and Collections of State Hist. Soc. of Wisconsin for 1856, p. 495. * Compare the same in New Jersey. Chapter ii.

[5] Annales des Mines, S. 5 T. x. page 411.

The analysis of thirteen specimens sent up to M. Rivot made in his own laboratory is as follows:

No. of Specimen.	Metallic iron.	Oxygen combined.	Gangue rock.	Alumina or clay.	Lime.	Water.
(7)	67.0	26.0	4.5	1.5	1.0	0.0
(13)	67.0	28.3	2.0	2.5	0.0	0.0
(6)	66.0	28.0	1.5	2.5	1.7	0.0
(8)	64.0	27.0	6.5	2.0	0.2	0.0
(4)	59.0	25.0	11.0	1.5	2.0	1.1
(1)	58.0	24.0	15.0	2.0	0.8	0.0
(5)	58.0	24.5	11.0	3.5	2.5	0.0
(12)	51.5	22.0	23.0	2.5	0.5	0.0
(9)	50.0	21.0	21.5	6.5	0.5	0.0
(2)	49.0	21.0	26.0	2.5	1.0	0.0
(3)	40.0	17.3	38.5	2.5	0.8	0.0
(11)	38.5	16.2	43.0	1.5	1.0	0.0
(10)	33.5	14.5	43.0	1.5	2.5	4.6

Foster and Whitney's Second Report of 1851, page 50 to 57, gives as the results of their examinations the fact "that the principal deposits of specular and magnetic iron ore are found connected with a belt of crystalline schists and intercalated trappean rocks, bounded on either side by a belt of granite extending east and west for more than thirty miles and in its widest expansion exceeding eight miles; and that, proceeding southward for forty miles along the eastern limits of the azoic system, there are numerous evidences of the existence of these ores, but nowhere observed to be developed on a scale of such magnitude or purity as in the belt above alluded to."

Starting from the shore of Lake Superior, near the mouth of Carp river, and proceeding westwardly, near the line between townships 47 and 48, we strike the first deposit of iron in the northeast corner of section 1, in township 47, range 27, distant about twelve miles from the lake shore. Throughout the northern, and especially the northeastern, portion of this township, the iron ores exist in inexhaustible quantity. The only township which, in point of accessibility, and in the abundance and purity of these ores, compares with that just mentioned, is that adjoining on the east (township 47, range 26) and near its southern boundary; although in reality a little nearer the lake than those before alluded to, they are inferior in the purity of the ore. In township 47, range 28, but few deposits of iron are known to exist, the surface being comparatively low and covered with drift. One or two quarter sections on the northern boundary have been marked with the symbol of iron (♂) in accordance with the notes of the linear surveyors, though we failed to find any beds of value. On the northern side of section 18, in this township, we found speci

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mens which indicated the existence of ore of a good quality in the neighborhood. In township 47, range 29, several localities of ore have been observed, in a line nearly due west from the great deposits described as occurring in range 27.

Proceeding still further west, in the next range (township 48, range 30), there are abundant traces of iron associated with hornblende rocks, along the northern shore of Machi-gummi, while in the adjoining township south, on section 1, and in the adjoining township east, on sections 6, 7 and 12, on the borders of the Machi-gamig river, these deposits are largely developed and possess a considerable degree of purity. It is presumed that these ores are prolonged in their range beyond the Machigamig, and in fact their existence, to a limited extent, has been ascertained by the linear surveyors; but the general surface of the region is here intersected by few ridges, and covered over with transported materials, effectually concealing the underlying rocks.

Further west, on the sources of the Bad river, Mr. Whittlesey, while connected with the survey of the Chippewa district, discovered numerous deposits of iron, in the azoic series, and under conditions similar to those which prevail here.

Crossing the Machi-gamig, the belt of azoic schists sweep to the south and southwest, intersecting the Menomonee river, along the southwestern boundary of our district. Throughout this portion of their range, the occurrence of these ores is by no means rare, but they are nowhere developed on such a scale, or exhibit so great a degree of purity as those in the vicinity of Teal lake; some of the beds, however, are valuable and may ultimately be made available. The most southerly deposits are in township 40, range 30, a few miles east of the Twin falls on the Menomonee river, and are among the most extensive and valuable in this portion of the district.

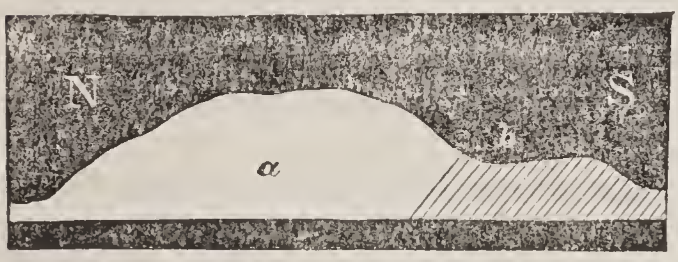
When it is remembered that nearly the whole of this region is an unbroken wilderness—without a human habitation, if we except the settlements along the valley of the Carp, or a trace of the labors of man, if we except the surveyor's lines, or the few blind Indian trails—it seems reasonable to suppose that, at this time, we have but an imperfect idea of the extent of these iron-bearing deposits. The more important masses have been discovered; but there are, undoubtedly, subordinate beds equal in purity and susceptible of being wrought, which will not be revealed until the axe shall level the forests, or the plough strip off the superficial covering.

From the above sketch of the geographical range of the principal deposits of iron, it will be noticed that in the belt of azoic rocks as far west as the Machi-gamig river they predominate along the northern side of township 47; so that if we take a line running due east and west between this township and that of 48, for a distance of about eighteen miles in length, we shall find nearly all the valuable deposits concentrated within a short distance to the north and south of that line. A tendency to the formation of a similar belt may be noticed along the southern side of township 47, where the azoic schists are in close proximity to the granite.

We proceed to a more detailed description of some of the more important iron deposits of this region.

Township 47, *Range* 26.—The principal deposits of specular and magnetic oxide of iron ore are on and near the line between sections 27, 28, 29 and 30, and sections 31, 32, 33 and 34; they are arranged in a metalliferous belt, bearing nearly east and west. In section 31, the iron ore is finely displayed in the bed and along the banks of a small stream which is one of the sources of the Escanaba river. At one point it is precipitated over a ledge of this ore, from a height of 37 feet, to which fall we have given the name of the "Iron Cascade." The ore is a peroxide of iron,

mixed with considerable silicious matter (see analysis), and seems to exhibit indistinct lines of bedding which dip at a high angle and are intersected at nearly right angles by joints which cut the mass into large tabular blocks. The quantity of the ore is evidently very great but covered with heavy accumulations of drift which line the stream on either side above the cascade, forming steep banks some fifty feet in height.[6] Proceeding eastward, we find, at the northeast corner of the section, and along the section line for the distance of a mile or two, at various points, the apparent prolongation of the same metalliferous band; but differing in character from that just described. The ore resembles the banded, jaspery deposit, on sections 10 and 11 of the same township, in the next range westerly, known as the Cleveland location. In fact, throughout the whole extent of the azoic series, up to the granite, which makes its appearance a little north of the south line of the township—the line of demarcation running nearly east and west along the whole of the township—the slaty rocks are so associated with the iron, that it is evident some great, general cause has operated throughout their whole extent to impregnate the entire mass with this metal. The relation of the schistose rocks and the associated ore may be seen from the following section, near the northeast corner of section 31: *a* is a compact, quartzose mass, highly charged with peroxide of iron, so as to be perfectly black, although distinct grains of quartz can be easily recognized in it. *b* is a somewhat slaty rock, resembling hornblende slate, also impregnated with iron, which occasionally forms in bands of quite pure ore, and in some places alternates with jaspery matter, as at numerous other localities. Much of the ore will yield from 40 to 50 per cent.



Along the line between sections 32 and 33, near the junction of the azoic schists with the granite, the relations of the iron and the slaty and quartzose rocks are finely displayed, in a ravine which extends for a considerable distance to the east and west of this line. The phenomena, here, are of the most complicated and interesting character. On the north side of the ravine, we have the slaty and quartzose rocks dipping at a high angle to the north, and presenting a great variety of mineralogical structure. Quartzose bands, composed of fine grains of silicious matter, impregnated with peroxide of iron, with occasional wide bands of pure ore, alternate with a hornblende rock, having a schistose structure, and equally charged with ferruginous matter. The whole appearance of the mass is that of a series of beds of quartzose and hornblendic matter, thoroughly impregnated with iron and greatly disturbed, and changed from their original structure and position. On the south side of the ravine, at a distance of a couple of hundred feet, a complicated succession of trappean and granitic belts, crossed by numerous veins of igneous rock, is presented. Here, however, the rock is no longer charged with iron.

Township 47, *Range* 27.—The deposits of iron, as before stated, are displayed on a grander scale than in any other portion of the district, and merit a special description.

The ferriferous band here forms a ridge about a thousand feet in width, and from

[6] Analysis: Perox. iron 66.03, Insoluble 32.63, of which 95.85 was Silica, 2.88 Peroxide iron and 1.27 earths.

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a few feet to fifty in height, above the general level of the surrounding country, and can be traced almost continuously across the section in an easterly and westerly direction. On the northern side of the belt, the ore is compact, and of great purity; near the centre it exhibits a banded structure, while, to the south, it passes again into the compact variety. The annexed section by Mr. Hill will serve to illustrate these changes, and show the connection of the iron with the associated rocks. 1. Chlorite slate. 2. Compact iron ore. 3. Iron and jasper, in alternating bands. 4. Hornblende and feldspar rock, highly crystalline. 5. Veins of quartz, containing ironglance, cutting the mass.

JACKSON ORE BED.

Whole width 1,000 feet.

The dip is about 62° to the north. Towards the centre of the mass, the ore is less pure, and passes into the banded variety. Numerous veins of quartz (5) cut the great mass of ore, and contain specular oxide in large, brilliant plates, which present quite a different appearance from the ore which they traverse. The character of the ore varies at different points; but, in general, it possesses a remarkable degree of purity—for a description and analysis of which, see the chemical composition of the iron ores in the succeeding chapter.[7] The iron has been worked to a limited extent in an open quarry, but there are loose blocks enough scattered along the base of the cliff to supply a furnace for many years. The same deposit, above described on section 1, continues westerly into section 2; but this latter section is far less valuable. The trappean rocks here form a bold ridge along its northern boundary, being a continuation of the ridge on section 1. In the sections still further west of this tier nothing of value has been discovered.

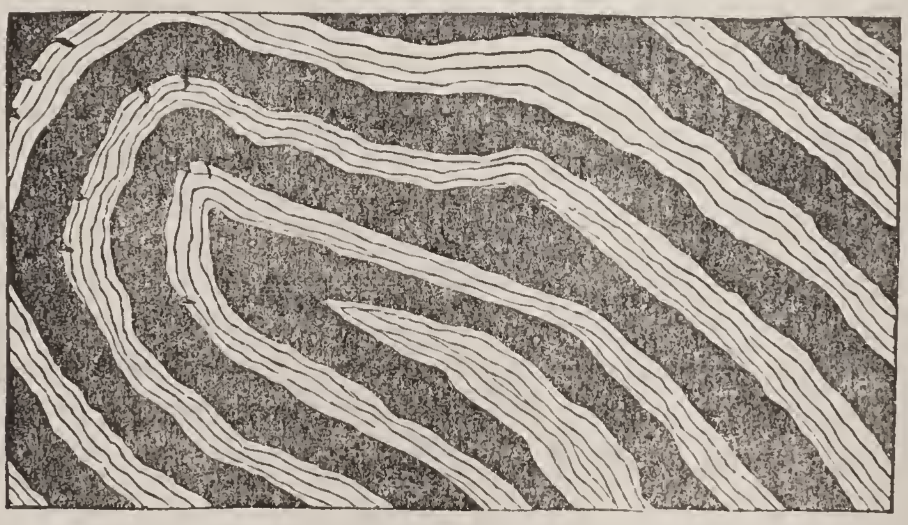
In the northeast corner of section 12, next south of section 1, there are evidences of a deposit of iron in the deep red soil and large masses of ore, which lie near the surface on the side of a hill, of which the summit is a crystalline trappean rock. No part of this section, however, has been reported as containing a workable deposit of ore.

In the next adjoining sections west (10 and 11), are deposits of ore on a scale of great magnitude; they are, in fact, unrivalled in the abundance and almost absolute purity of the ore. The purest ore occurs in a ridge, or elongated nob, which extends across the line between these two sections, about an eighth of a mile south of their northern boundary. It rises with precipitous walls to the height of at least fifty feet above the surrounding surface, and is made up of an almost chemically pure ore. It exhibits many of the characters of an igneous, eruptive rock, and cannot be regarded in any other light than as a huge lenticular mass, which has been elevated to its present position from beneath, while in a semi-fluid state, exactly in the same way as the trappean ridges which accompany it, and which it so strikingly resembles in general outline and position. The ores of this ridge, though in the highest degree of purity, differ somewhat in appearance at different points. The purest portions are a very compact and fine-grained specular ore, having an imperfect slaty structure, and traversed by joints, like the slates in the neighborhood.

[7] Oxygen 29.46, Iron 68.07, Insoluble 2.89, no trace of Manganese, Phosphorus or Sulphur.

Through this fine-grained base are scattered numerous, minute crystals of the magnetic oxide. In other places, the ore is almost entirely made up of an aggregate of crystals of the magnetic oxide, sometimes very minute, and rarely larger than a pin's head. Abundance of ore may be obtained in loose blocks, around the base of the ridge, and of a quality unrivalled for purity, containing between sixty-nine and seventy per cent of metallic iron.[8] The emanations of metallic matter have penetrated the adjoining slaty rocks in the vicinity of this locality, and filled them with crystals of magnetic oxide and occasional streaks and bands of fine-grained peroxide of iron. The thickness of the mass described above, or its linear extent, cannot be given with accuracy, as its limits are concealed by the heavy covering of drift which extends over the greater portion of this region; but it may be safely stated that this single locality is capable of furnishing an inexhaustible supply of ore; and that, too, without recourse being had to expensive underground mining.

Farther south, we find another deposit of ore crossing the line between the same sections (10 and 11), on a scale of still greater magnitude, though not equal in point of purity, to the ore last described; this is known as the Cleveland location. It rises in the form of an elongated knob, or ridge, to the height of one hundred and eighty feet above the small stream in the valley at its base, and one hundred and fifty-two feet above the drift terrace, over which the road passes near its northern slope. Its height above Lake Superior is 1,039 feet, and it forms the culminating point on this line, between the two lakes. This mountain of ore, for such it may be called, is no less remarkable for its magnitude, than for its extraordinary structure. It is made up, as far as it is exposed on its sides, which rise irregularly, and in some places with vertical walls, of alternate bands of pure fine-grained peroxide of iron and of jaspery ore. The thickness of the bands varies from that of a sheet of paper up to one-fourth of an inch. They are not arranged in a constant position, with regard to the general disposition of the mass; but are twisted and contorted in every variety of form and outline; the curvatures are, however, mostly on a very small scale, the radius of curvature in the concentrically folded layers being never as great as one foot in length. The deep-red color of the jaspery portion contrasts admirably with the steel-grey of the less silicious bands; indeed, the singular beauty presented to the eye on stripping off the mossy covering of a vertical wall thus decorated by innumerable fantastically-interwoven stripes of harmonizing and brilliant colors can hardly be exaggerated. We know of nothing resembling it elsewhere. This peculiarity of structure, as well as the convolutions, is represented in Plate xxi., Fig. 3. The width of this deposit of ore cannot be less, at its base, than



Peroxide 90.58, magnetic oxide 9.17, Silica .20, or Iron 70.22, Oxygen 29.53.

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a thousand feet, and it may be traced for considerably over a mile in length. It is probable that the deposit which occurs on the western line of this section, south of the trail, is a continuation of that just described. It appears in the form of a rounded knob, portions of which are of very pure ore, while, in other places, it exhibits the same banded structure as the more easterly portion of the ridge.

In the line of sections next south of 10, 11 and 12, namely, 13, 14 and 15, there is a large quantity of iron at numerous localities; but so far as we have examined them, they are much inferior in quality and purity to those just described. The metallic matter has apparently not been thrown up bodily in a fluid, or semi-fluid state; but has permeated the slaty, silicious rocks in the form of a sublimation from below, and is, therefore, not pure, being mixed with more or less foreign matter. At the southeastern corner of section 13, the hornblende slate is thus impregnated with iron, which occasionally forms in it streaks of quite pure ore, but not of any considerable thickness. The same may be said of numerous localities along the line between sections 13, 14 and 15, and sections 22, 23 and 24. In proportion, however, as we recede to the north or south of a band about a mile in width, occupying the northern portion of the township, we find the quantity and purity of the ore deteriorating.

Township 48, *Range* 30.—On the northern shore of Machi-gummi, iron has been observed at several localities, but it possesses no great purity. It is associated with compact hornblende and feldspar rocks, which may be eruptive in their origin. In some instances, it occurs in slates, when it partakes of the laminated structure characteristic of these deposits. In other instances, for example along the south boundary of section 32, township 48, range 30, it is associated with a rock in which quartz largely predominates: an association very common in the Adirondack ores of New York.

Township 46, *Ranges* 29 *and* 30.—The largest mass observed by us in this region occurs on the left bank of the Machi-gamig, in section 7, of township 46, range 29, and traces of it are to be observed on several of the adjoining sections. It here rises in a nearly vertical cliff to the height of one hundred and thirteen feet, and is somewhat variable in purity. For the most part, it has a slaty cleavage, and, on close inspection, is observed to be composed of alternating bands of micaceous specular iron and quartz, tinged red by the peroxide of iron; but there are occasional belts which display a granular texture, and apparently possess a greater degree of purity.[9] These laminæ are nearly vertical, exhibiting few contortions, and range with so much uniformity, that the observer would be inclined to refer both the slates and the iron to a common origin. Interlaminated with it, is a band of rock composed mainly of white, granular quartz, with traces of feldspar, through which are disseminated particles, as well as rounded masses, of specular iron. It is difficult to pronounce whether this is a conglomerate or a breccia. Notwithstanding the immense development of this iron, it was found impossible to determine its relations to the surrounding rocks, a fact of much importance in judging of its igneous, or metamorphic, origin. At several points, veins of pure white quartz were seen traversing the cliff, which contained iron glance, a form of this mineral which was nowhere noticed except in this association.

In the vicinity of portage No. 4, and on the right bank of the river, according to Mr. Burt, the same kind of specular iron is seen in ledges twenty and fifty feet in

[9] Analysis: Iron 37.73, Oxygen 14.95, Silica 46.92, trace of lime and magnesia.

height; and another exposure of equal magnitude was noticed on the north boundary of township 46, range 29; but in both instances the associated rocks were not recognized.

On the north boundary of township 43, range 31, Mr. John Burt observed a bed of iron possessing a considerable degree of purity, but of inconsiderable extent.

Township 40, *Range* 30.—This, as far as known, is the most southern position of the iron, and of course nearest to the navigable waters of Lake Michigan. Its position, however, as will be seen, is far less favorable than that of the deposits in the vicinity of Lake Superior, and we do not, therefore, believe the iron will become of practical value, at least within a reasonable time. According to Mr. Whittlesey's notes, the bed is exposed near the southwest corner of the township, at several points along the west side of a hill which is about one hundred feet in height; its breadth is from one to two hundred feet, showing nothing but slaty iron ore on its summit for a distance of forty rods. The real extent of this deposit is concealed by heavy accumulations of drift and boulders along its base and on the summit of the ridge; but it probably extends eastward for a considerable distance. The distance from this deposit to the Menomonee river is only two or three miles; this river would furnish a great amount of water power in the neighborhood of the ore, but is not navigable except for canoes, which can be carried round the numerous falls by portages. The quality of the ore does not appear, from the specimens collected, to be very good, it being mixed with more than half its weight of silicious matter. The surface of the township is so covered by burnt and fallen timber and a thick undergrowth of maple and poplar, that it is difficult to ascertain much with regard to the character of the subjacent rocks.

Township 40, *Range* 28.—In the south part of this township, on the line between sections 28 and 29, there is, according to Mr. Burt, a deposit of iron of considerable extent It is at least a hundred feet in breadth, and extends probably three-fourths of a mile in a linear direction. The specimens of the ore show a very high degree of purity, as they contain but little silicious matter, and are a mixture of the peroxide and magnetic oxide, yielding from 63 to 68 per cent of metallic iron. (See analysis). The course of the bed is N 80° east S 80° west, and the dip is 80° to the north. This is probably the most valuable deposit of ore in the southern portion of the district, thus far observed.

Township 42, *Range* 30.—In the southern part of this township large blocks of ore have been observed, but the bed was not discovered.

Townships 42 *and* 43, *Range* 32.—In these townships several localities of ore are reported by Mr. John Burt; but, as he remarks in his notes, they are not generally of sufficiently good quality, or extensive enough, to make them of much value. The ores of this portion of the district are generally much mixed with silicious matter, and far inferior to those of the deposits further to the northeast. (See analysis).

"The Lake Superior ore is replacing the black band ore in eastern Ohio, although costing three times as much per ton, the furnaces finding their profits in a far superior quality of metal, less coal, and more tons a day, by the use of Lake Superior ore. One of the best furnacemen in the bituminous coal region, Charles Howard, of Youngstown, now uses from three-fourths to all Lake Superior ore. Other furnaces are increasing their proportion of it also. Yet the black band is abundant, and with the other native ores are obtained very cheaply in the vicinity. But the black band will not make good iron, and is never used but in small proportions." (See letter signed T. p. 53, of Monck's American Mining Chronicle, N. York, May 22, 1858, and notes 462, etc. Table II, page 128 of the A I. A. Bulletin.)

Lake Superior.

North of Lake Superior at Gros Cap near Michipoten river, "dykes" of iron ore were discovered in 1851, facing the water, four hundred feet in height. A company was formed in Detroit to work it.[1]

CANADA.—The British Provinces of North America abound in various ores, although their mineral resources have hardly yet begun to be developed. An interesting collection of their ores of iron was exhibited by Mr. Logan, the Provincial Geologist, at the Great Exhibition in 1852. From his account of them, it appears that the magnetic and specular oxides are most abundantly distributed throughout the Provinces. They occur chiefly in a formation consisting of gneiss interstratified with important bands of a highly crystallized limestone, which sweeps through the Province from Lake Huron to Labrador, and connects near the Thousand Islands with the great azoic district of New York, already noticed as so rich in iron ores. The ore of Canada, as in New York, forms immense beds, interstratified with the gneiss, and dipping at a high angle. In the township of Marmora there is a bed 100 feet in thickness. In Madoc there is one which has been traced for several miles and found to have a breadth of 25 feet. This locality has been worked to some extent. At Myer's Lake in South Sherbrooke there is a 64 foot bed. In South Crosby a mass of ore 200 feet in thickness is also mentioned. These magnetic ores are 60 to 70 per cent metallic iron. Specular ore is also abundant. At Macnab is a bed of it 25 feet thick and most favorably situated in every respect.[2]

The Belmont beds of proto-peroxide of iron (fer oxidulé) which feed the Marmora forges of Upper Canada are intercalated among beds of crystalline limestone and green talc schist, in basin form, over a width of 40 yards. At Madoc, some leagues from Belmont, another bed occurs in mica schist 10 yards thick, extremely fine grained, often magnetic and polar, containing a little actinolite and small quantities of yellow uranite, and makes superior iron. The beds of the surrounding district are—at South Sherbrooke 25 yards wide,—at Crosby on the Rideau canal more than 60 yards wide,—at Hull on the Outaoua 35 yards wide in a dome or anticlinal wave. These beds are pure magnetic iron ore mixed only with a few hundredths of mica or quartz. The red hematite or compact *fer oxidulé* often replaces the foregoing variety, and occurs at Macnab on the Outaoua 9 yards thick in crystalline limestone, mixed with a little silex and carbonate of lime. An immense bed is said to exist on one of the isles of Lake Nipissing.[3]

The titaniferous iron ores of the Laurentian formation merit well the attention of mineralogists by their abundance and by

1 Amer. R. R. Jour. p. 525. 2 Whitney's Metallic Wealth, page 481.
3 Esquisse géologique du Canada. Paris, 1855.

their associations; although not adapted to the manufacture of iron, they are sources of titanium. Their principal layers in Canada are on the Bay of Saint Paul where may be seen a single mass 30 yards in thickness and more than 100 long, with many smaller ones inclosed in a feldspathic rock of the sixth system, a granular ilmenite of the Urals, affording to Sterry Hunt Titanic acid 48.60, Protoxide iron 37.06, peroxide iron 10.42, magnesia 3.60, containing pure transparent orange-red grains of titanic acid, rutile or brookite. These feldspar rocks in some places contain titaniferous iron in beds some inches wide, marking lines of stratification. Here will be the future mining region of titanium.[4]

Addendum.

While this first chapter was in press the author received the unbound sheets and plates of the second volume of H. D. Rogers's Final Report of the Geology of Pennsylvania, like the first volume, printed in Europe, and nominally published in Philadelphia by Lippincott & Co. Reserving for a more suitable place the reflections which these extraordinary books excite, I add here what is said in their chapter on the iron ores concerning the igneous origin of the primary ores and the nature of the Cornwall bed.

The magnetic iron ore occurs only in the form of true veins of injection or genuine mineral lodes. Its veins very generally coincide approximately in direction and inclination with the crystalline strata, between the layers of which they lie; yet this conformity is only partial, for when they are traced with close attention, they are occasionally found to intersect the strata for a short distance, and then resume their parallelism. These iron ores evidently reached the positions in which we thus find them while in a melted state, their intrusion being the result of an enormous subterraneous force, rupturing the earth's crust in the direction of the strata, or in the planes of weakest cohesion, and pressing the liquid ore and other fused mineral matter into the open fissures. Where the rent has been at all irregular or splintery, the vein which filled it is interrupted or uneven, being in some places pinched to very narrow dimensions by the approximation of its walls, in others dilating by their recession, and in many cases being split into two or more parallel branches by the insertion of a wedge-shaped portion of one or other wall. The veins incline at all angles between 45° and the perpendicular.

As a general rule, the lodes of magnetic iron ore of the chain of the Highlands, tracing them from the Schuylkill to the Delaware, and then across New Jersey and New York, give evidence, in the nature and mode of distribution of the included crystalline minerals, of their having in many cases derived at least a portion of these from the fusion of the minerals of the walls of the fissures into which the intensely-

[4] Esquisse géologique du Canada. Paris, 1855.

heated ore has flowed. It is indeed a very common fact that the foreign minerals in the ore are precisely such as would be produced by the melting[5] and re-crystallizing of the rocky matter in contact with the vein. I may mention, as worthy of record in this place, a general fact of some scientific and much practical value, in relation to the relative position of the oxide of iron and the non-metallic minerals in the same vein. Where the vein or dyke is large, and contains much extraneous mineral matter, this latter, if the inclination is not very steep or perpendicular, forms a separate division in the vein, and almost[6] invariably *rests upon the ore;* but where, on the other hand, the dip is nearly vertical, the earthy minerals and the ore are more intimately mingled, or the respective masses of each intersect, or inclose each other irregularly.

The origin of these different conditions of insulation of the materials is very obvious. The oxide of iron, while the whole mass of the vein was yet in a state of fusion and very fluid, would necessarily, from its greater relative weight, follow the lower wall of the fissure as it flowed to the surface, while the much lighter earthy minerals would float, as it were, upon the upper side of the ore, taking the position with respect to the latter of its scoria or cinder. This would arise wherever the slope of the fissure was sufficient to give the force of gravity much control in the distribution of the materials; but in all cases of a perpendicular vein there would be no tendency in the heavier metallic portion to collect on one side rather than on another, and therefore it and the lighter mass would mingle more promiscuously. I first detected these phenomena among the magnetic veins of Orange county, New York, where the ore is often accompanied by much white feldspathic granite, the product apparently of the fusion of the feldspathic gneiss of its walls; and I have become confirmed in my impression of their generality by an extensive study of the veins of iron ore of the entire chain of the Highlands, from the east side of New York to the river Schuylkill, and of many of the great magnetic dykes of the west side of Lake Champlain.

There are many veins which are not accompanied by any separate body of granitic matter, but contain the feldspar, hornblende, or other minerals in much abundance, disseminated through the ore. These we may imagine to have acquired their solid state, at least in the portions near the surface, where alone we can observe them, from a condition of imperfect fluidity, like that of the already half-chilled lava of some volcanic eruptions which would effectually prevent[7] the separation of the heavier from the lighter constituents. Such are some of the gneissoid iron veins of the South Mountains east of the Schuylkill. The Long Mine on the Sterling estate, 4 miles east of the Ramapo, in New York, is a good example of the characteristic features of these lodes of magnetic oxide of iron; it displays the outcrop of two veins, each reposing directly upon gneiss, and covered by a thick vein, or rather division of the same vein, consisting of coarse white feldspathic granite.[8]

The mode of mining these veins, where the dip is not excessively steep, is to leave numerous staunch pillars of the ore, and to remove by blasting that which intervenes. A partially columnar structure, or cleavage, is sometimes visible, as in the principal vein of the Sterling Long Mine, dividing the ore perpendicularly, or nearly

[5] Why not *dissolving* and re-crystallizing?

[6] It must be shown that this happens *in all cases.* There must be no exception as there is none in the casting floor of a blast-furnace. Otherwise one may as well say that the top shales of a coal bed were a scum on the fluid coal.

[7] And as effectually prevent the issue of the iron lava.

[8] Explained by repeated solutions and precipitations.

so, to the surfaces which confine it. It greatly facilitates the operations of the miner. This structure, so analogous to that of many basaltic and other igneous dykes, is by no means infrequent in the large veins of magnetic iron ore, and indicates a slow and gradual crystallization from a state of fluidity.[9]

Of the practical utility of the general fact which I have now announced respecting the frequent presence of some form of granite or unstratified rock, and the almost invariably overlying position which it occupies, one or two simple illustrations may be interesting. The first intimation usually procured of proximity to a vein of magnetic iron ore is by the local disturbance it produces in the magnetic compass; but as the indications of the position of the vein derived from this instrument are frequently very vague and perplexing, it is of the greatest value to have some independent geological clue to its situation. Such, approximately at least, may be found in the usually conspicuous granitic outcrop of the upper half of the vein.[1] When this is accompanied by a strong disturbing action upon the magnetic needle, we may infer, with a high degree of probability, that a metalliferous vein, large or small, lies immediately in contact with and below the dyke, and it is then only necessary to ascertain, from an inspection of the dip and direction of the adjoining gneiss, the lower edge of the granitic dyke, to have all the data requisite for finding the outcrop of the ore with very considerable certainty.

But this knowledge of the inferior position of the ore to the unstratified rock accompanying it, I have found useful in another way. It can be applied to tracing or recovering a vein of the ore thus overlaid by a mass of granite which has suddenly eluded the miner through the effect of some transverse fault or dislocation. Where the displacement, as usual, is to the extent of only a few yards, it is very obvious that, if the fault be an *upthrow*, the gneiss upon which the ore-vein rests will constitute the wall; whereas, if it be a *downthrow*, the granitic roof will lie athwart the original course of the vein.

Mr. Rogers then adds a few facts to those given in his first volume respecting the primary ores of the Easton-Reading range of Durham hills or South Mountain.

Near Durham iron-works, and not far from the creek, there is a valuable vein of magnetic iron ore, discovered a few years since, and now wrought for the furnaces. This lode varies in thickness from 2 to 14 feet, averaging about 6 feet. Its total length has not been ascertained, but up to the summer of 1856 a gangway had been driven along it for 850 feet. It ranges northeast and southwest, and dips 45°. The ore is pronounced rich and excellent. Within a few hundred feet of this lode there is a deposit of rich hematitic ore, thought to be derived from it. . . . . . The same variety of ore, of excellent quality, is found on the surface, near the top of the north gneissic ridge south of Allentown, at a spot a little west of the Philadelphia road. A less magnetic variety is met with on the north slope of the hill, a mile to the east of the road. Further to the southwest, the magnetic iron ore shows itself in the hill three miles southeast from Metztown, the spot being a little west of the Philadelphia road. It is on the south side of the second gneiss ridge from the north. The ore occurs in three regular veins, dipping with the adjoining strata at an angle of 50° to the south-southeast. The south vein is about $1\frac{1}{2}$ feet thick;

[9] Sandstones are thus cleft, and they have never been melted.

[1] This granite may have been a loose sandrock through which the iron settled to its place.

north of it occurs a stratum of rock (gneiss) 8 feet across, in contact with which is the middle vein, separated near its outcrop into two branches, which at a little depth unite into one vein; this is bounded on the north by a stratum of rock about 4 feet in thickness, and directly in contact with this is the third or north vein, having a thickness of 2 feet. The rock which incloses these several veins is a coarse regularly stratified gneiss, a mixture chiefly of quartz and feldspar.

Near Princetown, on Rauzbaun's farm, an old pit or shallow shaft has been reopened. The ore is highly magnetic, and of an excellent quality, but the vein is not a promising one, being only a few inches thick. At Roads's, nearly 2 miles east of Pricetown, there is a vein of superior magnetic iron ore, said to be between 5 and 6 feet thick. Its dip is perpendicular. In Alsace township, a vein of the ore has been opened 2½ miles south of the canal. This vein occurs in gneiss rock, and is double, being divided by a wedge of granite, or granitoid gneiss. The strata dip south 80°, and the vein has the same inclination. The whole thickness of the vein is about 8 feet, but the good ore measures only 4 feet, and this is in two veins of 2 feet each, the rest of the ore being very inferior.

Penn's Mount Ore-vein.—In the district we are now describing, though not strictly within the gneiss itself, there is an important vein of igneous iron ore, which has been wrought for some years. It is opened on Penn's Mount, about half a mile east of Reading. The vein apparently is injected conformably to the bedding of the primal white sandstone, and the ore is not accompanied by any bounding wall of igneous rock, but is in immediate contact with the sandstone itself. The latter rock disintegrates quickly on exposure to the atmosphere, and develops innumerable small grains of hornblende, which speckle the yellowish-grey sand. The ore-vein ranges from the Reading Fair ground, a little south of east, dipping 45° south. Its thickness is seldom less than 18 inches, and has been as great as 28 feet. Under this enlargement it does not appear to suffer in quality. The ore itself is of the granitoid variety, highly crystalline, containing quartz and feldspar, especially the latter, in great abundance: hornblende and apatite enter also into its composition. The vein has been wrought at its surface, outcropping in the Reading Fair ground, and for one-third of a mile east, by Eckert and Brother, the Phœnixville Iron Company, and others, on the lands of Mr. Oakley and B. Davis. The principal mine is the vertical shaft of Eckert and Brother: this is sunk 142 feet to the level of a tunnel, which is cut north 28 feet through rotten sandstone to the top of the vein. From this tunnel the vein is followed by a gangway 30 feet east and 115 feet west. The ore is worked along the foot-wall rising towards the surface, the hanging wall or roof being supported by timbers. The length of breast to the old surface-level workings is 72 feet. The ore from this old level was obtained at a depth of 82 feet. The Phœnixville Company are now obtaining their ore from a surface-level and whin-shaft east of Eckert's Mine. In Eckert's old level, 100 feet west of the whin-shaft, the vein split, but the north branch vein thinned away in 100 feet.

The *Island Mine*, situated on an island in the Schuylkill, one mile below Reading, has been wrought by Eckert, Syfert, and Company, but is now, perhaps temporarily, abandoned. The vein dips about 40° northwest. It is overlaid by dense brecciated limestone, locally known as "all sorts" limestone. This is, no doubt, the Mesozoic conglomerate, which appears in the opposite bank of the river *in situ*. The northwest dip of this rock has no doubt regulated the dip of the injected material. The under-rock of the vein we do not certainly know, but from the specimens seen it appears to be an impure silicious limestone, or that usually termed "bastard." The surface of the island is strewn with igneous rocks, but we are informed that none

are found in contact with the vein. The iron ore-vein, which is in thickness from a few inches to 15 feet, is a heavy, fine-grained slate-blue rock, containing lime in its constitution, and decomposing rapidly on exposure to the atmosphere. When decomposing, it assumes a deep sea-green color, and develops copperas on the surface, from the sulphuret of iron in the ore. In some specimens the pyrites have so much the aspect of sulphuret of copper that chemical evidence is required to correct the impression. A slope has been sunk upon the vein 90 feet below the surface, and, 28 feet above its foot, gangways are driven along the vein 20 feet towards the northeast, and 250 feet southwest.

About half a mile west of the preceding is the *Roudenbush Mine*, which, we are informed, yields its proprietors at the Phœnixville furnaces 5,000 tons of ore per annum The vein ranges a little north of east. Its foot-wall is white metamorphic limestone, or marble, and its hanging-wall, or roof, a dull sea-green serpentine-like rock, which on exposure soon crumbles down like ordinary shale. The vein, dipping 36° south, is followed by a slope 280 feet beneath the surface. At the bottom, gangways are driven 200 feet west, and 400 feet east, to a fault cutting out the vein. A higher level, 160 feet from the surface, is driven 300 feet east The ore is now taken from this level. Like all others, this vein is exceedingly variable; while wholly or almost entirely absent in some places, in others it has been found 30 feet thick. Its average bulk will not exceed 12 feet. The gangue-stone of the ore is a light-blue rotten limestone, from which the ore is scarcely distinguishable, except by its greater weight and deeper tint. Of the entire ground wrought, about one-half the material is sufficiently rich in iron for the furnace; the remaining rubbish is used as stopping in the old workings.

The *Wheatfield* Mining Company have opened a series of veins about 5 miles west of that last described. At this locality there are already proved about ten veins of igneous ore, ranging north and south, and all included within a transverse distance of 150 feet. The maximum thickness attained by any one of these veins is 8 feet. They are opened from the surface over an irregular area to a depth of about 40 feet, and have been followed along the outcrop from 50 to 110 feet. They occupy loose unstratified ground, including igneous rocks, to the depth at which they have been mined; and below that, as they are included in the beds of the Mesozoic conglomerate, they become pyritous, and are not wrought. The ore is similar in general aspect to that of the two last described mines. It frequently incloses fine crystals of calc-spar.

A narrow valley separates these veins as far as they have been traced north from an east and west vein, which is worked by a slope. This vein dips 30° south. It is underlaid by a foot-wall of trap, and overlaid by white crystalline marble. The thickness ranges between 2 and 12 feet. There is a strong admixture of lime in the ore. The slope is sunk 78 feet, and a gangway is driven 110 feet east.

In the range of the east and west vein of the Wheatfield Company, but a fourth of a mile further west, is situated the *Henry Ruth Mine*. The vein, which is, in all probability, the same, having similar walls both above and below, dips 25° south, and has exceeded 15 feet in thickness. The slope upon it is 120 feet long, and gangways are driven 45 feet west and 60 feet east. It has been also wrought at the surface outcrop.

The slates of the Primal series, especially the upper Primal slate, yield two classes of iron ore: one a very ferruginous variety of the rock itself, under conditions of more or less metamorphism; the other, a class of rich brown hematitic iron ore of superficial formation. To the first class belong the valuable and noted mines of

Cornwall, in Lebanon county, the Jones Mines in Berks, and partially the Chestnut Hill Mine near Columbia, and some of the ore diggings near Safe Harbor. At all of these localities the ore appears to be an original constituent of the Primal slate, but to have undergone a more or less degree of segregation from the substance of the rock by some agency connected with the metamorphism of the stratum. In many parts of the mass the oxide of iron is in a crystalline condition, dispersed in small specks throughout the other mineral constituents of the rock, which retains all its original features of stratification, and which resembles very much a mica-slate, or other metamorphic schist. This highly-altered ferruginous form of the rock is also in many instances subdivided by innumerable cleavage fissures, the effect of which has been to change the semi-crystalline magnetic iron ore to the ordinary brown peroxide or limonite by the copious admission of the surface waters and atmosphere into the body of the rock. In some spots, long exposed to abundant soakage through the cleavage-cracks, the iron ore is not only thus changed, but is actually collected into the deep narrow clefts of the rock worn by the percolation of the waters in the direction of the cleavage, so that in a cross section of the mine we may witness the curious anomaly of the ribbon structure or laminæ of stratification dipping one way, and the plates or veins of the accumulated iron ore, and its associated clay, dipping independently at a steep intersecting angle. The annexed little cut (Fig. 573) exhibits a synclinal basin of the Primal slate thus percolated with ore to a certain distance from the surface in the direction of the cleavage-fissures. An illustration of this mode of accumulation of the iron ore in the clefts connected with cleavage has been already furnished in Volume I., page 218, where a section is shown of the Rathfon Ore-bank, near Safe Harbor (see fig. 27), the only difference being, that the rock is the Auroral magnesian limestone, interstratified with talcoid slate, and not the Primal slate itself.

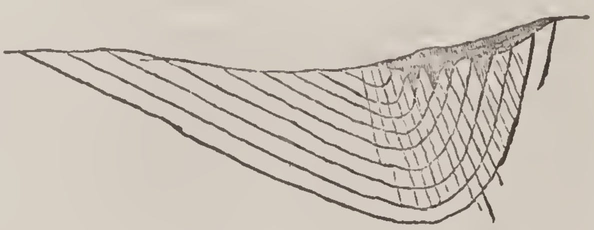


FIG. 573.

The other kind of ore derived from the Primal slates is the hydrated brown peroxide deposited upon the surface of the formation from the ferruginous loamy matter derived from the complete disintegration of the slaty rock. Nearly all the large deposits of the formation contain a greater or less proportion of this species of ore, and some of them consist of it almost exclusively. In the extensive open cutting called the Chestnut Hill Ore-bank, near Columbia, of which a description has already been given (Vol. I., p. 182), much ore is seen to pervade the lower layers of the altered Primal slate, while a large and dense body of the peroxide of iron has been accumulated at the very base of the formation, by a downward soaking of the surface-water collecting and concreting the ore in a dense and thick stratum or rude mass upon an impervious floor of close-grained Primal white sandstone.

The following circumstantial description of the iron mines at Cornwall, Lebanon county, shows the several phases under which both classes of the Primal ores, the segregated semi-crystalline and the concreted hematitic varieties, prevail. At this locality the actions collecting the oxide of iron into its present conditions have been somewhat complicated. The ferruginous Primal slate has been metamorphosed, and its oxide of iron segregated and crystallized through the influence probably of highly heated volcanic steam, and the same influence has produced a very general cleavage-structure. During the same action, or subsequently, numerous injections of molten hot lava, resulting in dykes of trap-rock, have invaded the stratum, and have still

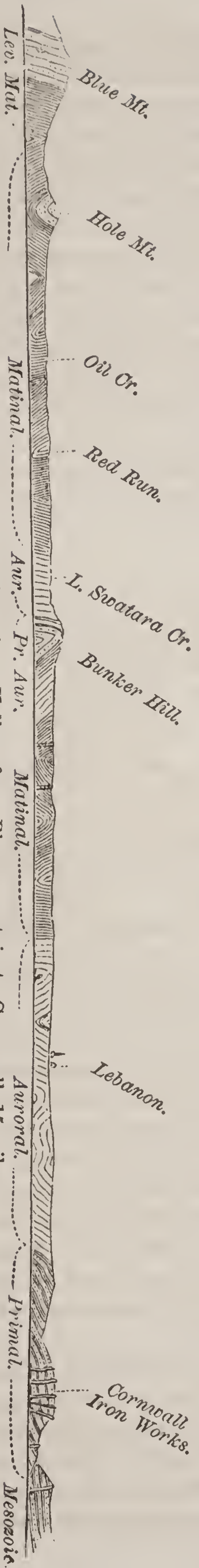


Fig. 574.—Section across Kittatinny Valley, from Blue mountain to Cornwall, 15 miles.

further changed the condition of the mass, infusing among it, probably by sublimation, some trappean mineral matter, and especially some sulphuret and carbonate of copper; and since these subterranean influences, the atmosphere, through its rains, has exerted itself through countless ages to modify still further the chemical and physical conditions of the shattered and fissured mass, and its contained oxide of iron.

Cornwall Iron Mines.—This great iron ore deposit, by far the most extensive, and one of the most interesting in the State, is situated at the outcrop of the Primal upper slates, where they rise from beneath the Auroral limestone in Lebanon county, on the southeast border of the Kittatinny valley. The geological relations of these mines on the border of the Kittatinny valley are shown in Fig. 574.

The ore strata are embraced in three hills, having a nearly east and west range. These hills are flanked to the north by the Auroral limestone, and south by the overlapping unconformable Mesozoic red sandstone, which forms a high ridge prolonged east and west, and overlooking the valley. Their position is five miles south of the town of Lebanon.

The eastern or "Big" Hill is elevated 312 feet above the level of the creek at its base. The middle hill is 98 feet high, and the western hill 78 feet high. The peculiar features of each of these will be considered in detail.

The bounding wall of the ore in the Big Hill is a heavy dyke of trap, which varies in regard to texture and composition as the feldspar or hornblendic element predominates. This massive dyke, the thickness of which seems nowhere less than 40 feet, and probably greatly exceeds this, encircles the hill on three sides, the south, east, and north, somewhat in form of a horseshoe. The north limb rises from the water-level at an angle of 60° or 70°; on descending to its water-level upon its south limb, the dyke bends sharply south, and is obscured by surface debris. Besides this general outer wall of trap, there are several smaller dykes of the same material; some of these appear to be offshoots from the main dyke, and are found in one or two instances interstratified with the ore. In other cases they appear as simple isolated columns of rock, surrounded by ore, and not traceable longitudinally through the hill, as the section would imply. At water level, on the west side of the hill, the two limbs of the ore inclosing trap are about 400 feet asunder, but on the hill-top, as a consequence of their opposing dips, they are 500 feet, or even 600 feet apart.

The ore in this hill is nearly horizontally, though irregularly stratified, and presents every possible aspect, from slaty greenish-grey to dark green and dark ferruginous brown and black: the latter variety is found chiefly in the vicinity of the trap dykes, and large masses are strewn extensively upon the hillsides, especially upon the north and south slopes. This variety,

known locally as the Nigger-head ore, is very highly endowed with magnetic polarity. As we recede from the vicinity of the intrusive rock, the ore becomes lighter in hue, and more slaty in texture. In parts of the mine these slaty portions are too poor in iron to be wrought. With the exception of those portions of the ore which are closely adjacent to the trap, the mass teems with crystals of sulphuret of iron; almost every hand-specimen displays many specks and small intersecting veins of it. This pyrites increases in abundance as the mining penetrates beneath the surface, or as the ore has been unaffected by atmospheric influences. Copper ore is found at times, in the form of green carbonate and grey oxide, impregnating the iron ore, but it does not appear as a vein, nor is it in contact with the dykes of trap, though probably introduced at the time of their intrusion. The iron ore hitherto obtained from the Big Hill has been taken from shallow excavations at the surface; it is now wrought exclusively at the west base, where successive benches are cut down from the surface

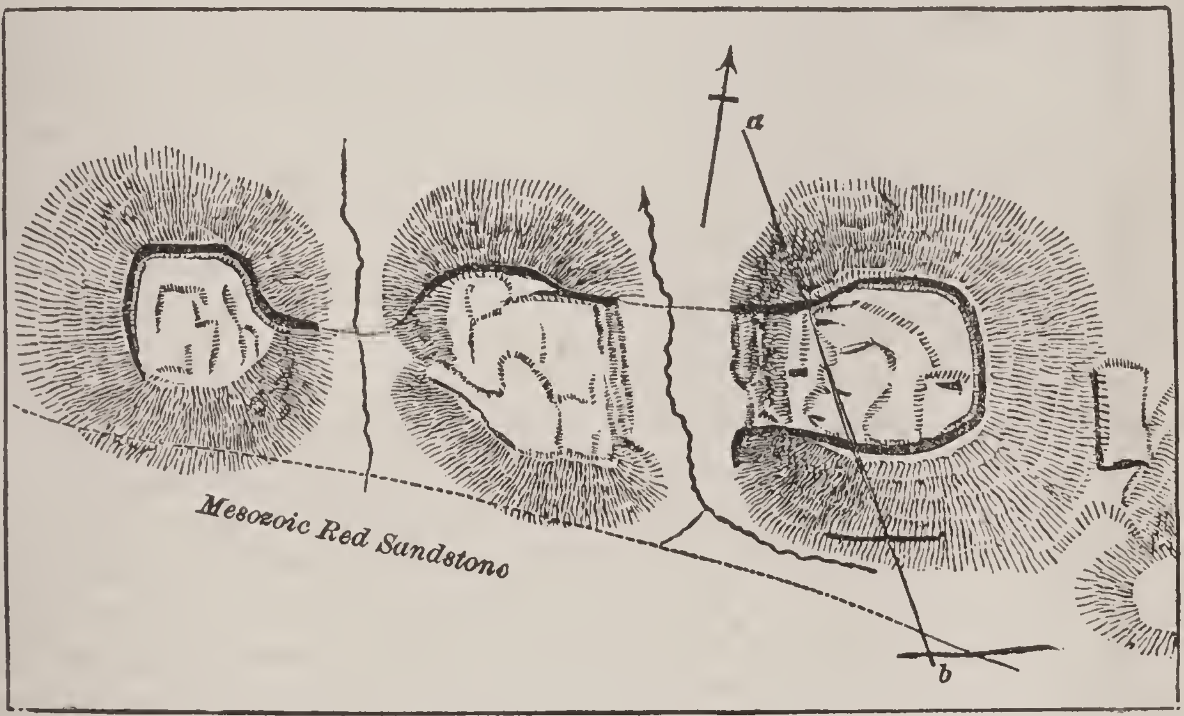


Fig. 575.—Map of the Cornwall Ore Hills, Lebanon County.

to the railway level. At the east base of the Big Hill there is a smaller rectangular excavation (See Fig. 578) of black and yellow crumbly ore, the bedding of which is nearly vertical, ranging north and south parallel to the face of a trap dyke which bounds it. This wall of trap is parallel to the east edge of the Big Hill, 200 yards distant; whether it is the outer face of the same great dyke has not been determined. On the east side of the pit another dyke of trap is visible, but the excavation has not been sufficiently extensive to determine its range or amount. A third narrow dyke crosses the south end of the excavation. The ore at this mine is granular and black, chiefly crystalline, or dark grey, in the vicinity of the trap; and in other places it is yellow and dark green, from atmospheric action.

The Middle Hill, separated from the Big Hill by a narrow valley, through which flows a small stream known as Saddler's Run, is that from which at present the ore of the district is chiefly obtained. The north wall of the ore is the prolongation west of the trap dyke which forms its north boundary in the Big Hill. This dyke ranges west through the Middle Hill, deflecting gently south along its west slope; it then crosses the valley, separating this from the west ore-hill, and soon after turns

north, then west, and finally curves south round the end of the latter, and is lost to view. Owing to the south turn of the southern limbs of the dyke at the west base of the Big Hill, it does not cross the valley, and does not appear in either of the two west hills, in both of which the boundary of the ore at the surface is formed by the overlapping debris of red sandstone and conglomerate from the neighboring hills. The general appearance and character of the ore in the Middle and Western hills is similar to that of the Big Hill. It is slaty throughout, and very pyritous; for which reason it soon crumbles under exposure. In those parts of the mine where the ore has been cut down cheese-like by the miners, the natural bedding of the mass is curiously contorted and irregular along a general horizontal plane. On the south side of the Middle Hill, the excavation has reached the water-level. In the pit, large masses of light blue flinty and magnesian limestone are found imbedded with and surrounded by ore. They are devoid of regular form. In like manner, masses of quartz are found as bunches in the bedding of the more slaty ore. In some of these, thin scales of native arborescent copper occur, though not abundantly. The white cupreous quartz seems to be derived from a vein of that material. The limestone is evidently not *in situ.*

Fig. 776.—Section through Cornwall Iron Mines, Lebanon County, along line *a b*.

On the Middle Hill several small veins or bunches of copper have been wrought to a limited extent. Four of these range north and south, with one exception dipping west. The direction of the strike is at right angles to that of the iron ore, which dips north about 30° in this part of the mine. The thickness of these veins varies between half an inch and three inches. A fifth vein may be traced on an east and west range at the south limit of the mine. This lode is occasionally entirely absent, but is in some places a foot in thickness, dip south 45° to 50°. It should be remarked that these lodes of copper are thick where the iron ore is soft, and that they thin away when the bounding walls of the iron ore are hard and pyritous. The usual varieties of copper ore extracted are grey protoxide, bright red binoxide, green and blue carbonates of copper, intermixed with sesquioxide of iron and iron pyrites; also rich specimens of the sulphuret associated with green and blue carbonates of copper. The lodes are nearly all accompanied by veins of green steatite. They have not been traced across the ore-deposit to the bounding trap-rock, but have been found within 50 yards of it, growing perceptibly thinner. When followed below the surface, they become poor in good ore, and merge into copper and iron pyrites. The annual yield in copper ore does not exceed 100 tons. It is smelted in Baltimore, and yields, we are informed, from 15 to 23 per cent of copper. The average annual product of iron ore is about 120,000 tons, but the mine is susceptible of being wrought

upon almost any scale. A small ore pit, from which no ore is at present extracted, known as the Doner Mine, is situated one and a half miles east of Cornwall. The ore, though of the magnetic variety, appears in irregular bunches and nests. No trap injections are found in the vicinity. The deposit is quite near the limestone, and is intermixed with sand and gravel.

By whom the 577 cut on Mr. Rogers's 719th page was executed he does not inform us, and it is comparatively recent. How Mr. Rogers, who prides himself upon being the *inventor of orographic science* can so lay himself open to the charge of not being able to read his own best sketches according to the plainest of the laws which he pretends to have himself discovered is strange. He talks of "numerous injections of molten hot lava, resulting in dykes of trap rock, invading the stratum of ferruginous primal slate and *still further* changing the condition of the mass, infusing among it, probably by sublimation, some trappean mineral matter," etc. etc. But he does not appear to have even noticed the concentric synclinal structure of this ore bed. Have we not here in fact a *bottom lining* of trap; over this a precipitation of ore; within this again a second canoe of trap; then a

FIG. 577.—Big Mine Ore Hill, Cornwall Iron Mines, Lebanon County.

a. Rich Iron Ore.
b. Slaty Iron Ore and Slate.
c. Solid Iron Ore, Slate fused.
d. Solid Iron Ore and Copper Ore.
e. Boulders of Magnetic Hematite and Trap.

sediment of mingled mud and iron; finally a third and most interior precipitate of trap in the form of a very small canoe? If his fig. 577 be worth anything it tells this tale and no other. His fig. 576 tells the same tale on the ground plan. Who ever heard of an *oval* ejection of lava dipping all round inwards like a woman's baking-pan? Yet such is the rim of trap in fig. 575. And fig. 576 carries out the explanation (although its lines of trap seem to have been forced, to avoid the consequence, or turned downwards to suggest a common vent), by showing that originally the synclinal was a valley and when once filled with its successive precipitations of trap and iron ore and shale, has resisted the *subsequent* denudation and been left, as it ought to be according to the laws of topography, the summit of a hill, or range of hills. This is what Mr. Rogers's figures teach, whatever his text may say and whatever the facts may be. It is quite possible that the trap, *if* igneous, overflowed horizontally in successive lavas, and was afterwards doubled up into the steep synclinal. But such a supposition would require other facts apparently not at hand. The disappearance of the southern edge of the dyke under the New Red debris (see page 495) and the presence of limestone and flint boulders in the ore, with the presence of native copper crystallized, form a curious mixture of circumstances pointing to drainage from a Lower Silurian surface into a New Red basin without an outlet. The cross-veins of copper look like subsequently formed fissures, infiltrated with materials from the then overlying, or from the now neighboring New Red. And in one word the trap, since it holds the ore as in a cup, announces its New Red age, for the trap is a New Red rock.

BROWN.

CHAPTER II.

THE BROWN HEMATITE ORES.

The deposits of brown hematite are thrown into this chapter by themselves, not because they are a separate chemical or geological formation from the primary ores discussed in Chapter I, but because they constitute practically and geographically a great group by themselves, and have, over and above this distinction, certain chemical and geological characteristics also. Before treating them in view of their geological age and relationships however, something more must be advanced in support of views which are of practical value in theorizing and therefore in professionally practising in geology; views also, which are becoming standard in the science by virtue of the comparatively late triple alliance effected between chemists, mineralogists and structural geologists. Having just stated these views of the primary ores, and now again of the brown hematites, it will be needful to give a geological sketch of the palæozoic or older secondary system of the American rocks, in the successive formations of which, from No. I the Potsdam sandstone at the base, to No. XII the coal measures at the top, these brown hematite beds occur. Then will come in place the detailed and local description of the deposits, with the iron works for which, in a Paleyozoic sense they were created.

Bischof devotes many pages of his immense work to the metamorphosis of carbonate of iron (iron spar) into brown hematite and also into red hematite and magnetic iron ore,[1] and then proceeds to discuss the remarkable fact that brown hematite changes to red hematite, showing that the water of crystallization or composition escapes voluntarily at ordinary temperature, whereas in the chemist's hands it refuses to go except at a white or glow heat. Analogous facts however offer themselves in common life. Becquerel found iron bars in the foundations of an old castle converted into hydrated oxide, magnetic oxide and

[1] Geologie, i. p. 1341.

peroxide, the latter showing itself as Elba crystals under the lens, and the magnetic oxide was likewise crystallized. R. Mallet found long exposed and very old rust (brown hematite and more or less carbonate of iron) to have lost its water and become anhydrous red oxide.

The bright red color of red oxide is no positive proof that it is anhydrous, and therefore some of the so-called red specular iron ores are probably more or less hydrous. Bischof got from a boiling solution of a peroxide iron salt, by adding a boiling alkali solution, a red (instead of a yellow) precipitate which yielded him 7.11 and finally 10.56 per cent water; and from a boiling solution of iron chloride with boiling salammoniac a still darker precipitate containing 15.26 water. The red color is therefore deceptive and must submit to a chemical test. Water boiled half an hour over iron ochre does not change its color. A change of color occurs only at the moment of production of hydrated oxide at boiling heat; not when hydrated oxide is treated with boiling water. The water percentage of the natural hydrate varies much. Herman's spring ore contained 25.63 water; fibrous hematite 14.71 water; needle ore, lepedokrokite, pyrosiderite, göthite, stelpnosiderite, etc. 10.31 water; Herman's Uralian Tunga river ore 5.33 water. Most of these are deposited from cold water and seldom from hot water. Some of the differences may be produced by a gradual loss of water. In Rammelsberg's range of analyses are many combinations which vary greatly from any atomic compound known. When amorphous brown hematite passes into red or anhydrous hematite crystals, we may suppose the water driven off by the very act of crystallization, although there exists fibrous and needle-formed brown or hydrous hematite.[2]

In the reverse order the red hematites pass back into brown or hydrated hematite. On Elba, vast and deep bodies of this ore have been so changed, says Kranz.[3] It seems as if the porosity of a mass of specular ore must limit the action of waters upon it to effect this change. When limestone meets ironglanz as at Elba, the calcareous waters probably produce the change, and this has been the agency producing the brown hematite deposits along the outcrops of the Lower Silurian rocks of the

[2] Bischof, i. 1350. [3] Same.

United States. Kranz did not show proper change-pseudomorphs of hydrous to anhydrous iron; but Blum found such in Oberstein amethyst balls.[4] Sillem describes a specimen the upper layer of which is botryoidal red oxide, all under which has been converted into brown oxide, the latter penetrating the former from within outward, and a breccia of red oxide pebbles with limestone and quartz showing a passage to brown oxide from outside inward. Volger devotes an opening chapter of great beauty to their exhibition in a specimen which he accidentally found in the collection of the Zurich college, where he teaches. The discussion to which it gives rise is of such importance to the subject that I give it as nearly as space will permit in his own words.

"The oxidized iron ores, the only ores of iron practically considered by iron manufactures, are the *oxydhydrate*, the *oxydul-carbonate*, the *oxyd* as well amorphous (hæmatite) as crystalline (glanz) and the *magnet.* These form a circle of development which has been set clearly before our eyes by the excellent labors of Haidinger, especially in his paper on Der rothe Glaskopf eine Pseudomorphose nach braunem, etc. Prag, 1846. A multitude of specimens from many localities have established and completely illustrated this circle. It would be a fair design to pursue this Protean metal through all its innumerable combinations and construct the coördinated circles which should be connected with this as their primary type. There are materials enough collected—in fact the difficulty arises from their overwhelming abundance. As yet, we have not even the first glimmer of the law which governs here and must be revealed to us hereafter. Iron cannot certainly assume the forms of *all* other minerals; the number must be limited; in the limitation lies the law if we had but made it. And the law of the lower limitations will reveal a more general law, a wider circle of these pseudomorphic phenomena, a grander system of mineral development."

In the collection at Zurich, Volger alighted on a specimen which showed to his trained eye with the assistance of a microscope the changes above mentioned, in the order mentioned, but beginning with carbonate of lime, that is one step further back. A very elaborate description of this specimen he gives

[4] Bischof, ii. 1351.

on pages 223 to 233 of his Studien. It consists of five successive layers, two of calcspar and three of quartz, alternately arranged, so changed into the various ores of iron as to preserve the original crystallization of the spar and yet show all the steps of the process by which its substance came to be replaced. We have here, he then goes on to say, in a space of two inches, a great variety of phenomena, yes in a space sometimes scarcely a single line thick the whole perfected range of iron ores: iron spar, ironoxydhydrate, redironstone, ironglanz and magnetiron and all indubitably in genetic connection. The specimen should be labelled: Magnetiron, ironglanz and hematite in the form of (nach, or *after*) ironoxydhydrate *after* ironspar in *substitution-pseudomorphs after* calcspar. It is clear how the development has gone on. The more soluble calcspar was dissolved out and the less soluble ironoxydulcarbonate precipitated in its place. Ironspar exchanged its carbonic acid (in the change of oxydul to oxyd) for water. Water at a later date escaped again from combination. Ironoxyd remained, as an amorphous residuum of the oxydhydrate. Still later began this amorphous oxyd to crystallize.

Native iron can undoubtedly issue from magnetic iron, but yet is nowhere seen to have done so in nature. Magnetic iron on the contrary which is the first or lowest phase of iron oxidation seen in nature (when sulphur and arsenic are absent) occurs as a pseudomorph of ironspar, that is, is found cast into the crystalline form or mould of carbonate-iron (oxydulcarbonat). These are the two ends of the range or poles of the circle of development above mentioned, between which lie all the others and especially the immense quantities of natural oxides or hematites. Volger has shown,[5] and Blum has supported him in his demonstration,[6] how many pseudomorphs have not contented themselves with one but have taken several or even all the steps of this great range of change, and that both as to their whole mass bodily, or only as to their parts, atom by atom, some parts having gone further or changed more than others, and thus showing in a single specimen many or even all the steps of the process, all the stages of the development. Once there was a time when the egg, the worm, the pupa, the butterfly were

[5] Uber die pseudomorphosen der Fahlerze, in Poggend. Ann. 1849, Bd. 74, s. 25.
[6] Zweiter nachtrag zu dem pseudom. des Mineralreiches 1852, s. 87.

not known to be the same creature in successive stages of development. Now the whole law of the change is made out, and so is the analogous law of the crystalline transformation of carbonate-iron to hydrous hematite, then to amorphous anhydrous hematite, then to specular ore, and finally to magnetic ore. Iron glanz was the consequence; and this again losing some of its oxygen became magnetic iron. This and no other was the order of development. The facts speak for themselves. But there is no theory. How the development was energized is not explained. The riddle of the causes is unread. We may imagine what agents or powers we please, the facts pronounced by the crystallization of this and similar specimens remain unchanged. So much we can say, that no fire agency would have left a hydrate here among the crystals. Haidinger's celebrated Anogenesis and Katogenesis theory [7] can be shown to fail in the explanation, Volger thinks. The simplest explanation is the best. Waters holding in solution ironoxydsesquicarbonate replaces calcspar with ironspar. Water holding oxygen (in the absence of stronger deoxygenizing agents) attacking ironspar must convert it to ironhydrate. For the reduction of oxyd to oxydul (per- to prot-oxide) which evidently also occurred, we must call in the powerful deoxidizing *organic substances* suspended in all waters. That these were present the burnt smell of a pseudomorph heated to a glow in a glass bulb shows. But when we come to the change of the hydrate to anhydrate, and the anhydrate red mass to anhydrate black crystal, no explanation is at hand; we only know that the fact repeats itself infinitely in the iron mines of the world.

Volger then gives, from page 236 on, the data for all these changes from the mining observations of the best writers of modern days. In treating of the peroxide showing itself in the forms of the hydrate, carbonate, etc. (page 248 to 264), Volger says:

Rotheisenstein is **amorphous oxide of iron;** crystallized oxide, which seems red only when in the most delicately thin plates, as *eisenrahm*, by transmitted light, is ironglanz. The red iron reflects the red rays and therefore looks red. The crystallized iron lets the rays through and therefore remains black

[7] Uber die Pseudomorphosen und ihre anogene und katogene Bildung, Prag, 1844.

by reflection and is only red when semi-transparent, and held up to the sun. The distinction is not only curious but important, affording another instance of a mineral existing in two dissimilar forms or conditions. Iron oxide is merely the caput mortuum of the hydrate, a residue which can only appear in the form of that of which it is a residue, namely the hydrate. When it takes on a form of its own it becomes glance or specular iron. This formless or amorphous residue, whether as red glatzkopf, or as compact, or as ochreous hematite, and this other crystallized residue, whether as translucent mica-iron (eisenrahm), or as scaly ironglimmer, or as fine Elba specimens, present two stages of development in the history of iron ores. The red hematite never comes from specular ore; **specular ore always comes from red hematite.** In the red hematite either the unaided eye or the microscope can always detect the incipient crystallizations as fine black points. . . . . .

Magnetic iron is found changed into peroxide not only at the outcrop of veins but in the case of isolated crystals disseminated through rocks. The change is recognized by the old crystalline form being preserved. Blum finds octahedral peroxide in the Tyrol of a fine cherry red, with some of the crystals coated with red oxide; the coating sometimes burst and the ochre within protruding; the crystals scarcely or not at all magnetic. Also in Brazil and again in chlorite slates, some of the magnetic crystals changed and some still unchanged. Weibye describes such pseudomorphs with unchanged magnetic crystals and hornblende in Sweden. Rose describes multitudes of fine octahedrons partly hematized in serpentine. The change in all these cases is effected by the protoxide (30.98) joined with the peroxide (69.02) in the compound magnetic ore taking to itself an additional 3.44 per cent of oxygen, when the whole mass becomes a homogeneous peroxide 3.44 per cent heavier than it was before, and 3.44 per cent bulkier also, seeing that the mean specific gravities of the two oxides are the same. When *Martite* is thus formed the increase of volume must amount to 8.62 per cent of what it was before. The thrust of various kinds of crystals variously lying athwart each others' axes of polarity due to this increase of volume must occasion interstices and produce in turn a diminution of specific gravity.[8]

The deposit of hematite or the peroxide of iron is described by Bischof in connection with the decomposition of basalt to wacke and wacke to clayslate![9] The peroxides of iron and manganese (brown iron stone and pyrolusite) obey so closely the same laws and are found so generally together that they must be treated alike in the discussion. Manganese is in extraordinary quantity in basalt (6.0 per cent), in which iron is much less abundant (0.6), and Bischof expresses his surprise that although a small amount of iron is found with oxide of iron in analyzing pyrolusite, he should never have been able to find a trace of the oxide of manganese with oxide of iron in analyzing brown iron stone. His query is why should the two metals so kindred be so utterly disallied and separated in a common decomposition? The

[8] Bischof, ii. p. 600. [9] Geologie, ii. p. 805.

reply is, of course, to throw doubt on the fact of their common origin from basalt; a suggestion which of itself is startling enough to a geologist. He offers however a more acceptable alternative, viz., a common decomposition from wacke (sandstone or sandy slate). The oxides of both metals have undoubtedly been leached out of masses of sedimentary rocks and deposited where the leaching fluids found a quiet level, whether inside or outside of the surface.

At a recent meeting of the Boston Society of Natural History, Dr. A. A. Hayes stated that he had proved, from eareful analysis and examinations of pseudomorphs, as well as the more ordinary forms of hematite, that the infiltration of an aqueous solution of silicates of proto-peroxides of iron and manganese, *caused the production of hematite.* The beautiful black, glossy covering, which confers so much beauty on the ores of iron not truly hematites, as well as the ore of manganese, is always composed of silicate of proto-peroxide of iron, with silicate of one or both oxides of manganese; and the compact peroxides of manganese, often owe their density and hardness to this compound.[1]

It has been already remarked how intimately the hematites and sulphurets are related in all rocks, primary or metamorphic and also secondary or unchanged, and equally or even in a still higher degree in the tertiary or recent deposits. The great double-sulphuret beds of Tennessee and Virginia as well as less well known sulphur-iron gneiss rocks of the azoic system have been seen to pass at the surface into brown hematite beds. So do all the sulphuret and carbonate beds of the palæozoic and kainozoic systems, whether they be great or small, more or less impure, whatever be their alloying contents, whatever be their structural status or lithological arrangement. In fact we are almost ready for the expression of a general law that all iron ores *beneath* the surface crystallize into magnetite, and *at* the surface into limonite. *At the surface* in such a formula must of course be understood to mean as far down as the disintegrating influences of the atmospheric waters reach; and by *all ores* must be meant a general term which takes for granted as already known the chemico-sedimentary varieties of original deposit. It is true that muds and marls of every geological age have accepted and retained sulphur in combination with iron in proportion to the amount of organic matter then existing on the surface of the earth, or at least within their water-basins. But no one has yet succinctly and demonstrably made out the exact steps of the process by which these sulphurets of iron became limonite or brown hematite deposits. Nor will the attempt be made here which has always, at least partially, failed in the ablest

[1] Annual of Sci. Dis. 1858, p. 295.

hands. It will be enough to point out what has been and is still the course of inquiry and discovery in this direction.

Iron pyrites in stone coal is a universal accident well discussed by Von Dechen and Schmidt,[2] which last mentions (what every one conversant with many coal fields must be aware of by his own observation) the occurrence in coal beds of pieces of wood half turned into lignite and half into pyrites. In many cases the whole form is occupied by pyrites. Nöggerath informed Bischof in conversation that the appearance of pyrites with lignite (holz or faser-kohle, fäserige anthracit) so common in stone coal repeats itself in the brown coal beds of the Lower Rhine. The faserkohl occurs precisely in those beds where the pyrites abounds and especially those explored for the alum factories; is more or less surrounded by or inclosed in pyrites or gypsum; and is accompanied by brown iron ore evidently derived from pyrites. The oxidation of the organic remains (wood, etc.) has decomposed the sulphur salts, hydrogen being probably the first oxidized, and the carbonization going on thereby more rapidly. The sulphuric acid being set free seizes on the oxide of iron in the vegetable matter and forms pyrites. The organic soluble materials have disappeared from solid stone and brown coal, and perhaps one part (sulphate of potassa) has given its sulphur to help form the pyrites. Red birch wood ashes contain enough sulphuric acid and oxide of iron for 48,077 parts of this kind of wood to make one part of pyrites. A log of 20 cubic feet could afford 130½ grains of pyrites. Moreover its proportion of iron is 23 times as much as its sulphur requires and is therefore on hand to make that much more pyrites when sulphur-waters come along. The needle-leaf trees are still more abundant in these materials than the broad leaf trees, and they were the trees of the older coal measures. The fir can make 10 times as much pyrites as the beech. No wonder then that pyrites is so universal a constituent of rocks of every age, since oxide of iron, salts of sulphur and organic remains have never been wanting in any age. The fucous class of plants, the sea-weeds, which preceded higher vegetations are eminently rich in sulphuric acid. Nineteen analyses by Forchhammer give a range from 1.28 up to 8.50 (the mean being 3.82) per cent of

[2] Nöggerath, das Gebrige in Rheinland-Westphalen, ii. 1 + iv. 1 +. See Bischof, page 922.

sulphuric acid, combined with potassa, soda and lime. When fucus vesiculosus for example is allowed to decompose, its fermentation in a few days gives off carbonic acid and results in alcohol, when the change of the sulphur salts to sulphur metals sets in, developing sulphuretted hydrogen to such a degree on some coasts, *e. g.* at Copenhagen, as to tarnish family plate in the chests of country seats. Let iron oxide now be at hand and pyrites must form, the oxygen passing from it to ally itself with the potassium, calcium and sodium of the sea-weed. An iron spring issues from the oölite in the island Bornholm among sea-weed and covers the whole bed of the sea with a beautiful yellow coating of pyrites; but where the waves flow and ebb and this pyrites is left periodically exposed to the air, it turns to sulphate of the peroxide of iron. So ferruginous clays when they cover up sea-weed present to it the needful elements for pyrites, which afterwards forms sulphate of protoxide of iron, and if lime is wanting, finally becomes sulphate of alumina; if present, then gypsum. Hence the abundance of alum and pyrites in the palæozoic shales and slates. The oldest silurian rocks of Scandinavia contain mighty deposits of alum slates, in which the naked eye can detect no pyrites, except in particular layers where it is especially abundant.

If the ultraplutonists, says Bischof, allow that pyrites can form in the wet way in sedimentary rocks, they nevertheless insist upon its appearance in plutonic rocks where it must, they think, have an igneous origin. But when we examine its origin there more closely it will turn out to be secondary. There is scarcely a kind of crystallized stone in which pyrites does not here and there occur, old granite, gneiss, mica-slate, chlorite-slate, syenite, porphyry, and young basalt, diorite, dolerite, trachyte, hornblendite, serpentine, alike, not in the cracks but in the body of the rock, and sometimes so finely that its presence is not suspected until the surface weathers to a brown hematite hue. But either these crystalline rocks possessed originally the pyritous elements or else waters possessing them have permeated these rocks. In the first sense sulphuric alkalies are common in crystalline rocks, and iron never fails. If room be wanted it is obtained when, for instance, the 23 per cent of sulphur in sulphate of soda unites with the 66 per cent of iron in oxide of iron, making pyrites of a much less bulk than the original com-

pounds. Into the iron thus made mountain-waters bring in new materials, and from these again new installments of pyrites are made. If the small quantity of sulphate of soda in the original rock be objected, there are other more copious sources at hand.[3] The ultraplutonists must acknowledge that if heat were applied to a rock holding pyrites, it would drive off some of the sulphur and leave a lower sulphide. To escape this difficulty they resort to the hypothesis of *pressure*. It is true by experiment that pressure can retain the volatile elements of a compound; but no experiment has ever shown that pressure can reverse the relationships of the elements of a compound. Barruel heated intensely in thick pistol-barrels a mixture of carbonate of lime and pyrites, yet the natural interchange was made and sulphide of calcium resulted. Can the plutonists say that were the pressure greater the sulphur and the iron would have been kept apart? Where then is their sulphide of calcium in their fire rocks? Heat pyrites with basalt, diorite or any other silicate of lime under strong pressure and sulphide of calcium must result. Certainly it would if the basalt etc. contained calcspar. By all that has been said (concludes Bischof) we know that every pyrites, occur where it may, must be regarded as a secondary formation originating chemically in the moist way.[4]

Iron pyrites Berzelius found could be made out of powdered or amorphous peroxide with sulphuretted-hydrogen. The little particles of disseminated pyrites seen through a microscope (says Bischof) of from 70 to 600 linear magnifying power, show right angles, suggesting the cubic form, but perhaps due to a tabular crystallization; under the highest powers they show hairy rays issuing in indeterminate directions.[5]

The proportion of sulphur in the earth must be very great when we remember the volumes of sulphurous gases issuing without intermission from all active volcanoes and solfataras and from many caverns and springs. The vapors of the Columbian crater Parace form solid crusts of sulphur eighteen inches thick, and cover wood exposed for a few days with a coating of crystals. The inaccessible rocks around the great Armenian volcano Alaghez are so covered with it, that the inhabitants shoot it down with rifle bal.s. The Japanese call their Tanao-

[3] Geologie, i. p. 930. [4] Vol. i. p. 936. [5] Géologie, ii. p. 278.

sima and Jevo-sima *sulphur* islands. The caves of the Grecian Milo are full of sulphur and alum, and the floor of sulphurous earth burns blue like the surface of Milton's pandemonian lake. Sicily is the sulphur market of Europe, preparing its ware by melting a clay which contains it in mechanical admixture.[6] In all ages sulphur and clay were deposited together; and from these under-ground deposits rise the innumerable sulphur-springs; like salt wells from deposits of salt and sandstone. The earliest ages of the planet, when volcanic movements were more numerous and on a grander scale, the sea continually received accessions of sulphates from the land and pure sulphur from the air, so that there is not a slate formation in the palæozoic series which is not charged with sulphuret of iron in disseminated crystals, and with native sulphur in fine threads and seams within its cleavage planes. Considering the fact that sulphuret of iron is more abundant in the coal measures than in any other formation, and the fact that plants[7] and animals[8] contain sulphur in their physical composition, its presence in the shales or clay formations might be ascribed to the presence in all river, beach and shore muds, in the bottom of ponds and marshy springs, of finely comminuted vegetable and animal matter. So far as the rocks range down from the present age to the beginning of the animal and vegetable life, throughout the quarternary, tertiary and secondary eras the explanation is sufficient for its purpose; but when all evidences of life upon the planet disappear, the explanation fails. It is true that the apparent first appearance of organized creatures may not be the true beginning of organized life. The scolithus linearis worm-tube casts of the Potsdam sandstone at the base of the Palæozoic system in America, have their analogues not only in the Lower Silurian rocks of western England but far down below them in the Cambrian or primary sand and mud slates of a greatly older date. Nevertheless, throughout the primary Huronian system beneath the Potsdam sandstone of Canada and the Atlantic seaboard, and throughout the still vaster and older Laurentian system beneath it, wherein no trace of organized life has ever

[6] Von Leonhard, trans. Balt. 1839, p. 99.

[7] For example *garlic* and other liliaceæ, *mustard* and other cruciferæ, *assafœtida* and other umbelliferæ.

[8] In their eggs, urine, etc.

been seen, sulphur abounds. The argument is still but negative, for the metamorphic agency may have obliterated the traces of organized life; but for the present we must consider sulphur to be a primary and volcanic rock in mass, and appropriated upon their appearance afterwards by the physical economy of living creatures. The mud sediments of succeeding palæozoic and tertiary ages may then be looked upon as charged with sulphur through their death and decomposition.

The presence of the carbonate of iron and the sulphuret of iron together in the clayslate formations is a chemical problem of some difficulty. When sulphuret of iron receives oxygen, becomes sulphate of iron and meets carbonate of lime (limestone), it exchanges its iron for lime and there is produced sulphate of lime (gypsum); but never carbonate of iron; always oxide of iron, brown hematite, bog ore. In the coal measures sulphuret of iron is abundant in the coal beds, sulphate of iron flows abundant down the streams and through the rocks, but the limestone beds are never changed to gypsum. The exceptions in Nova Scotia, southern Virginia and elsewhere only make the rule more glaringly legible. The limestones wear away in caverns, their cleavage cracks become wide fissures, and they receive in these and upon their upper surfaces loads of brown hematite iron ore with traces of zinc and lead thrown down upon them by a leaching process, which involves the sulphuret of iron disseminated through the rocks; but they never become gypsum. These beds of brown hematite show however by their very posture that the carbonate of iron, distributed in plates, in balls and in the finest granular dissemination through the shales above, and not the sulphuret of iron, was their original. Whatever sulphuret of iron there is among the balls of carbonate serves only to make the brown hematite beds a little sulphurous and their ore a little red-short. So far as the coal measures are concerned, therefore the brown hematites are ores deposited not from pyritous slates but from shales surcharged with more or less segregated carbonate of iron. Whence then this carbonate? It is said that when the oxidized pyrites or sulphate of iron meets the carbonate of lime the latter carries off the sulphuric acid and the iron becomes limonite and then red oxide.

Regarding for the present only the older brown hematite ores; in the second annual report of the Pennsylvania geological sur-

vey[9] Mr. Rogers expresses in a sufficiently open way his original views of these beds, as resultants of a general ferruginous mud deposit against the north base of the South mountain, it acting as breakwater to a deluge coming from the north. No such theory, involving the same errors that lie at the base of Prof. Hitchcock's tertiary hypothesis, appears in the first volume of his Final Report, and therefore it is proper to suppose that he has abandoned it. He does not even repeat his observation that the principal beds of brown hematite occur along the southern or lower margin of the Lower Silurian Limestone II; those along the northern or upper margin being abnormal or occasional. Any ocean, of tertiary or any other age, covering the Appalachian belt of parallel mountains and valleys, must be conceived as doing so either at once or gradually, either forcibly or gently, and as either deep or shallow. If at once and forcibly, from the northward, then all the brown hematite beds should lie along the north bases of all the mountains. It is needless to say that they do not; in fact a topographical denudation theory established on such a basis breaks down at every point. If the ocean was a deep and gradual submersion of the continent and quiet in its action, except like all oceans around its shores, its deposits would be very homogeneous, and then local rich brown hematite beds would be impossible. If the ocean were shallow in the back valleys against the Alleghany mountains it would be deep in the great front valley, and produce quite different effects over the self-same formations. If it were shallow in the great valley it would leave the back valleys dry and without deposits. But the absence of all true terraces, raised beaches and universal deposits contemporaneous with any such submergence sets the question of a quiet ocean-covering at rest. On the other hand, one of Roger's emigrating polar oceans would be much more likely to clean out the limestone valleys of their brown hematite deposits than furnish them with these. There remains then only the hypothesis of local weathering, with freshets, pools, swamps, and what not, requisite to fill deep cavities left by the original violent denudation of the surface to its present level. In this hypothesis local ferruginous rocks supply materials close at hand for local deposits of brown hematite; and as these ferruginous rocks will occupy constant positions in the series of the formations, the brown hematite

[9] 1838, p. 28.

deposits from their wear and tear will lie in outcrop lines upon the mass. As the ferruginous formations are principally slates containing sulphuret of iron and native sulphur, the brown hematites will lie along the borders of the slate formations, I, II, V, VIII, XIII, against the face of lower compact sandstone or massive limestone formations as the case may be. Nor must it be overlooked that the heaviest deposits of these brown hematites have been where the rocks receiving them lie pretty flat and the ideal section lines of the ferruginous slates rise but a few feet or yards above them into the air. The cause of the subsequent denudation of the latter may be hard to explain, but as we know that decomposition reduces hard ferruginous slate-masses to a brown soft clay pulp under which lie the concreted layers of brown hematite ore, the same process would allow the slates thus turned to clay to be entirely swept off by any sufficient subsequent denuding agency and the hard ore below to remain behind.

Whitney pronounces the brown hematites of western Massachusetts of tertiary age,[1] and refers to the careful studies made of them by Mr. Hodge.[2] But Mr. Hodge is convinced that Dr. Hitchcock's tertiary theory of these deposits has been too hastily adopted.

"It has long been known to geologists," says Dr. Hitchcock,[3] "that numerous deposits of brown hematite iron ore, associated with ochres and mottled clays, occur, in connection with a highly ferruginous limestone and micaceous and argillaceous slates, through the whole distance from Canada to Georgia; lying along the west side of the crystalline and hypozoic strata of the Green, Hoosac and some ranges of the Appalachian mountains. No geologist has doubted that these deposits were all contemporaneous; but their true age has been a mystery. During the year 1852, my attention was drawn to one of these deposits, in Brandon, Vermont, which has the peculiarity of containing a bed of carbonaceous matter twenty feet thick, with fifteen or twenty species of fossil fruits. The leading result of my examination is, that the Brandon deposit belongs to a tertiary formation, and the carbonaceous matter is very much like

[1] Metallic Wealth, p. 460–1. [2] Amer. R. R. Journal, No. 684.
[3] In his Geology of the Globe, page 105.

the brown coal of Germany. And since that, for the most part, belongs to the Pliocene or newer tertiary, we may provisionally place the Vermont deposit in the same place, and, by parity of reasoning, all the brown hematite beds, extending at least twelve hundred miles through the United States. So confident am I of the soundness of these conclusions, that I have ventured to mark a strip of tertiary on the map near the line along which the hematite beds occur, although they are not always in a continuous line, but scattered over a considerable breadth of surface. I do not, however, regard it so certain that this deposit is Pliocene tertiary, that I have ventured to mark it as such, but only as tertiary."

"The fruits of the Brandon deposit are beautifully preserved, but they are quite peculiar, and as yet their affinities have not been made out. A few of them are represented on the plates (95, 96). A full account of them, with the inferences, is given in the *American Journal of Science* for January, 1853."

We respectfully dissent from the opinion expressed in this passage that "no geologist has doubted that these deposits were all contemporaneous." On the contrary, the fact that they occur in belts along the outcrops of different limestones of very widely different ages is prima facie evidence that they themselves are of different ages. Were they *of one age*, in the ordinary sense in which the terms are used, and especially were they all of tertiary age, deposited long subsequent to the uplifting and denuding of the older rocks on which they lie, then, as every geologist will grant, they would be found outspread indifferently on any one or all of the older deposits, precisely as the coal measures of Illinois are seen to lie. They certainly would not be confined precisely to the limestone valleys, and precisely to the lines or bands of limestone outcrop; so that Lower Silurian Formation No. II has its own set, and Upper Silurian Formation No. VI has its own set. Still less would this particular arrangement of localities extend a thousand miles. And least of all would it become so minutely careful of its alliances as always to attach the ore deposits to particular members of these limestone formations, as for example to the lower part of No. II, and to two or more belts in the lower part of No. II. The distinguished and revered geologist of Amherst had studied these ores within the limits of the most metamorphic, disturbed and difficult section

of the Appalachian range, as Dr. Emmons did the Lower Silurian Formations themselves, mistaking them on that account for an older Taconic system. Where they spread out unchanged to the southwest they reveal their character. So with these brown hematite ore beds; when studied in Pennsylvania and Virginia they are seen to be not contemporaneous and late, in the sense applied, but attachés of very old formations of different dates.

In one sense however they are contemporaneous deposits. They are the weathered or perhaps they are the degraded outcrops of the Silurian limestone formations on which they lie. If weathered merely, they belong to that unknown epoch subsequent to the coal when this part of the continent emerged, its topography fashioned, and its outcrops offered to the atmospheric agencies. Subsequently, intenser action than mere atmospheric was, perhaps repeatedly, applied to these outcrops and how much of an accumulation of brown hematite ore and sand and clay was produced at one and how much at another time cannot be demonstrated or perhaps even estimated. Certainly it is not credible that, if all these local effects were produced at one time, and that a tertiary time, the evidences of the era in tertiary fruits etc. would be confined to one small point at the extreme northern limit of the range, to Brandon and its lignite bed alone.

But more than this, if more be needed, there is no sufficient evidence upon the ground at Brandon in Vermont that the brown hematite, the lignite and the kaolin, are related to each other in any such fixed way as to insure the fact that they are, *per se* and not as a mere local and exceptional deposit, contemporaneous. This lignite bed is one of the most extraordinary and unaccountable items in our thesaurus of geological events; a plug of coal; no bed; not horizontal; vertically or obliquely plunged, stem like, towards the centre of the earth; faced on one side with kaolin and impinging on the other against one of several deposits of brown iron ore. One might almost as well argue the age of an old oak from the analysis of an iron wedge found imbedded beneath its bark.

Kaolin is the clay which fills the hollows of the surface, or composes its subsoil, in the vicinity of granite and gneiss rocks consisting in large part of soda-feldspar. Potassa-feldspar does

not disintegrate, but soda-feldspar does, the surface of the rock becoming in the rain a paste of kaolin which slips or is washed down to its base or carried off by rills and brooks to be deposited in still water pools. Such was undoubtedly the origin of the Brandon deposit, and tertiary leaves and fruit were washed into the same hole perhaps at the same time.

This Brandon deposit of clay, lignite, oxide of iron and oxide of manganese, covered with sand and sunk in a pit of limestone, finds a curious parallel in the Balymacadam clay and lignite deposit in county Tipperary in Ireland, which is in like manner walled by Mountain Limestone and occupies not over an acre and a half. The clay is white or bluish, more or less pure, smooth and tenacious; the lignite, brown and decomposed, partly scattered through the clay, but found in a bed of varying thickness at a depth of 15 feet under it. Under these fragments of trees lies pure white soapy clay.[4] Sink holes occur in the neighborhood, and doubtless all *such* deposits are of tertiary or some late age, made in sink holes the egress from which below has been accidentally sealed.

Professor Rogers with his usual quickness of perception and as early as in his report of 1836[5] on the geology of New Jersey, without alluding to the tertiary theory, stated the alternative of *weathering* or *denudation;* since the ores are only found in limestone[6] they must be originally connected with it; either as already formed deposits denuded into sight along the present section line of surface; or as disseminated through the limestone and collected by the drainage into surface inequalities. He gives no preference to one or other of these two explanations, further than one in favor of the first may be implied by stating that common columnar or pipe ore has been discovered mixed with ferruginous loam and inclosed in limestone near Belvedere, the cavities being several feet in diameter. "We may suppose that many such exist," he adds, "and that the reduction or breaking up of the strata by slow or violent agencies has scattered the hematite through the superficial soil." We may also suppose these cavities of any size, by supposing original

4 Brit. Ass. 1857. A. B. Wynne.

5 P. 116.

6 The Pochunk mountain and other ores are inclosed in clays between the gneiss and limestone.

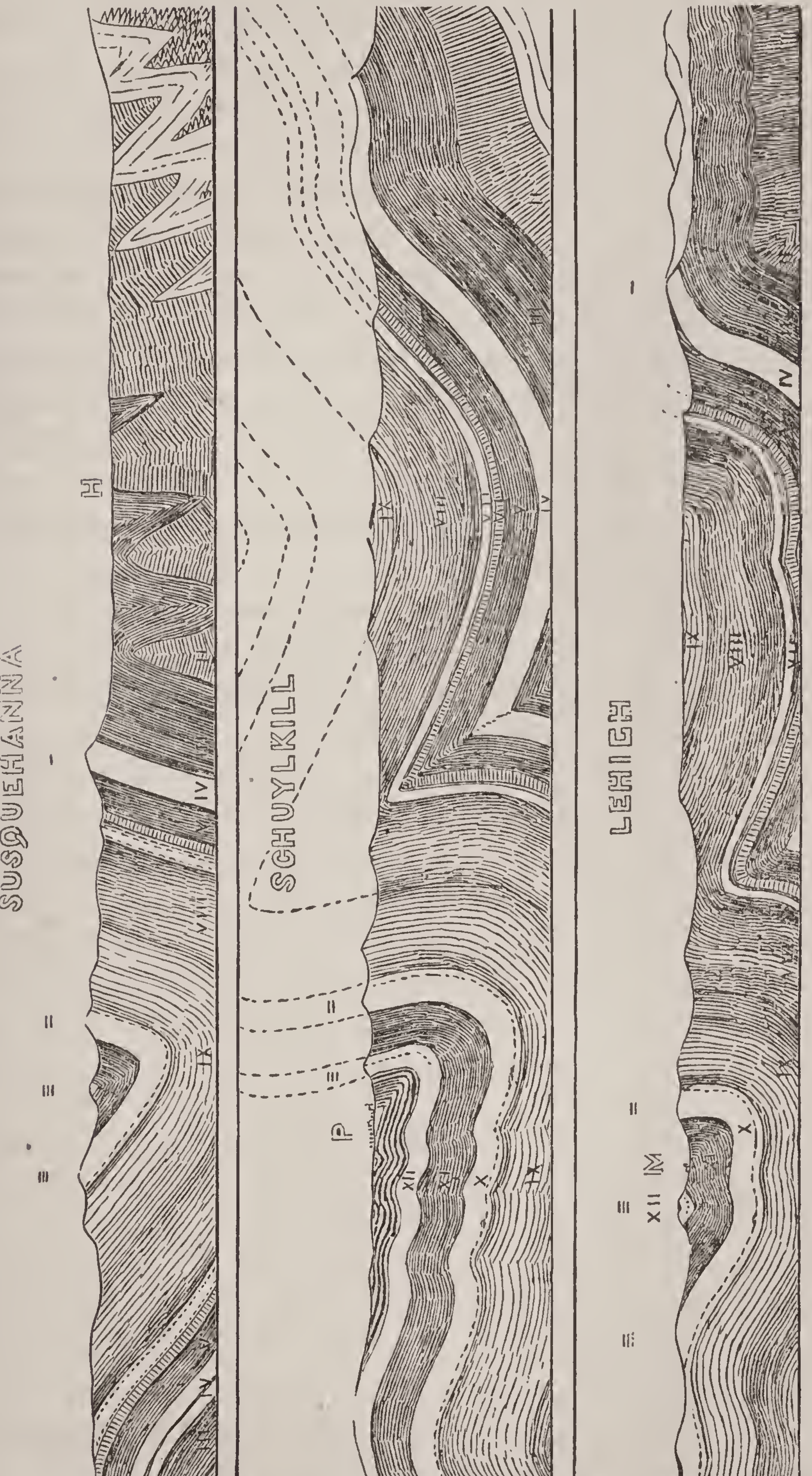
deposits of not a few hundredweight but many thousand tons of iron in the Lower Silurian limestone era.

These beds of brown hematite iron ore impress the reverent mind with the same admiration and gratitude that the poets and orators of science have so well expressed in view of the exhaustless stores of coal. If Faraday could grow eloquent over "the silent, tranquil, ever progressing, metamorphic changes involved in the phenomena of decomposition and decay" contrasted with the spasmodic efforts of nature, majestic and imposing though they be, and bespeaking our observation and riveting our attention by their occasional grandeur, there is no enthusiasm more judicious and well ordered by its objects than that of the iron manufacturer who sees in these concealed deposits the wisdom and affection of the Creator for his future offspring. Inexhaustible provision of fuel on one side and equally inexhaustible provision of stock on the other; the carbon concentrated into coal and kept pure and strong for its work, here, by the same eternally operating laws of decay which, there, has concentrated, softened and weakened the ore for its transmutation into iron. In both cases half the work is done, and done for man before he was brought upon the ground. In both cases he has half the work still left to do, by which his powers may be improved. Had the coal been stored away as wood, the labor of mining would have been added to that of charring; and had the iron not been oxidized and gathered into heaps, it would have remained forever out of man's reach or defied for endless generations his metallurgic skill. Nature meets man half way; she oxidized the ore for the ancients to teach them how to smelt, and kept back her anthracite until the apparatus of the moderns was prepared to use such concentrated energy.

The series of which the coal formation is the last has received the now generally accepted name of **Palæozoic**, or the rocks containing the relics of the Ancient Life. Those which follow the coal are called rocks of the Middle Life, Mesozoic. Those which belong to the most recent times and to our own new life, are called Kainozoic. In the great hematite belt of the United States, we are concerned only with the Palæozoic strata which underlie the coal for which they form a floor, in some parts seven miles thick. Along the banks of the Schuylkill, Susquehanna, Juniata, Potomac, and New Rivers, they are so thrown up and

stand upon their edges that they can be measured directly through from top to bottom, from the coal down to the Potsdam

Fig. 8.



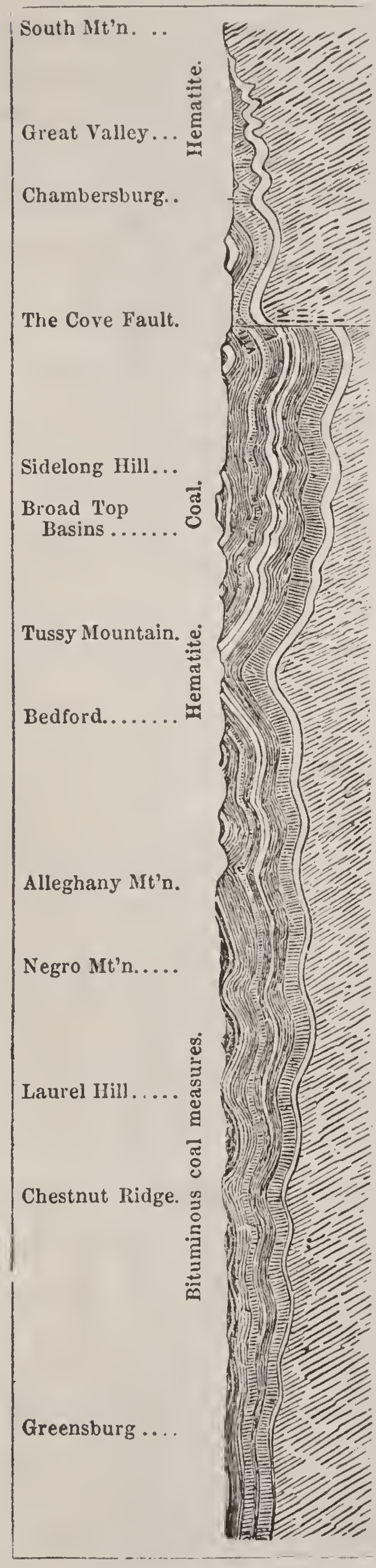
Sections in Pennsylvania across the Palæozoic Strata, Silurian and Carboniferous.

—Blue Mountain. — Second Mountain. ☰Sharp Mountain. ☰Peters' Mountain.

H. Harrisburg. P. Pottsville. M. Mauchchunk.

sandstone, No. I; and this not once or twice, but many times, as they alternately rise and fal. in a succession of vaults and basins; the basins being solidly preserved beneath the surface, but the vaults swept away into the Atlantic. (See Fig. 8, representing three sections north and south through Mauchchunk, Pottsville and Harrisburg in Pennsylvania; through the Kittatinny, Second, Sharp, and Peters' mountains.) The coal and other upper measures, where they spanned the vaults, are of course gone. Where they remain, they exist in narrow troughs along the centre lines of the great basins. As we ascend the Atlantic rivers to their heads, and approach the Alleghany mountain, these vast flexures of the crust suddenly give place to broad low arches, and shallow troughs, permitting the coal measures with their carbonate iron ores a wide expanse in each, as seen in the accompanying diagram, Fig. 9, which represents a section through Chambersburg and Greensburg in Pennsylvania. Finally the whole becomes nearly flat, and the coal spreads out and covers all, far into Ohio, Kentucky, and Tennessee. Then a broad wave brings up the under parts of the floor again across the western parts of Ohio and Indiana, and the coal, of course, is swept away. Beyond this, in Michigan, Western Kentucky and Illinois and far into Iowa and Missouri, the coal comes on again in fragmentary sheets and isolated patches deposited upon different portions of the floor,

Fig. 9.



according as that had been more or less cut through by the previous action of the denuding forces, until in western Missouri and Kansas it broadens into a continental field greater than its eastern Appalachian area but so concealed beneath the Mesozoic and Kainozoic systems that only its western edges are perceived where they emerge aganst the first ranges of the Rocky mountains.

This immense floor of Palæozoic rocks consists of four distinct repetitions on a grand scale of conglomerate and sandstone rocks, marking four great epochs of oceanic activity during the Palæozoic age, and of mud and limestone rocks between them, which were deposited during long alternate intervals of peace. Each of these **four sand-rocks** marks a new era in the geology, introduces a new creation of plant and animal, and draws its own distinct and separate topographical lines across the face of the earth. That complicated system of mountains which begins at the Hudson and ends in Alabama, obeying to the eye (even as obscurely drawn upon the common maps) evident laws of fixed relationship and parallelism, is seen to be, when studied out, merely the repeated outcrops or edges of these four great sand-rocks as they rise upon the waves or plunge again into the basins side by side. And the valleys which always follow round and forever keep apart the mountains whichever way they run, or however they may double back upon their course or fold themselves in zigzags, are in like manner the outcrops or edges of the softer intermediate limestones, slates and shales.

To understand the causes of these topographical or geographical appearances when these are portrayed on a map or studied on the ground it is necessary to recognize the few and simple laws which govern the construction and define the forms of mountains.

A Mountain has **three Elements,** top, side, and end, and the primary discussion of a mountain is that of its slopes, its crest-line, and its termini. Gaps are irregularities in its crest-line, as terraces are in its slopes. The cross-section of a mountain shows why its slopes, and usually also why its crest-line and its termini are not only what they are, but could not be different. It is a deep set feeling among men that if there be accidental forms upon earth they are to be found in mountains. There could not be a greater mistake; for if there be natural

forms unalterably predestined by the direction and intensity of natural forces they are those of mountains. Not a wrinkle in the side, not a notch in the crest, not a flexure in the trend of a mountain or a hill but is an evidence of laws which have operated upon it with the nicest precision. Not a ravine, not a rod of cliff, not a waterfall, but exists in the immediate vicinity of its own explanations. The place where a stream breaks through, however apparently accidental, was determined by positive relationships between the rocks of the locality; nor can any investigation be more exciting than that which rewards itself with perpetual discoveries of cause and effect in a wilderness of apparent lawlessness and unexplained confusion.

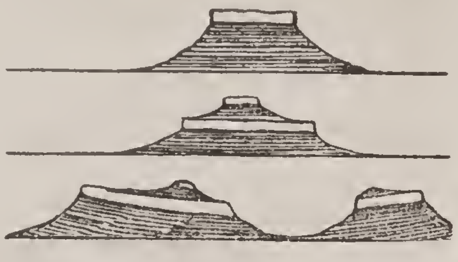
The Mountain Slope.—To illustrate the influence which its interior structure has upon the form of a mountain, the accompanying series of cross sections are introduced. The first set show how a stratum of sand-rock or other hard material, inclosed in softer stuff, arranges the height and slopes of its mountain to

suit its own dip. When it is vertical the mountain is low, sharp, and symmetrical; at 60°, it is higher with a front side long; at 30°, higher still, with a long, gently sloping back, and short steep front covered with angular fragments from a range of cliffs above; when horizontal, the mountain is at its maximum height, forming a tableland with precipices and steep slopes in front. It is needless to suggest the infinite variations of this simplest law of mountain form.

When two such sand-rocks lie in neighborhood they of course form a double mountain, subject to the same vicissitudes of external aspect in view of similar changes of internal structure. It is not so easy to show the effect of these changes under another influence, that of subsidence beneath a universal plane of denudation. The attempt, however, is made in the following sets of cross sections. It must be understood that a mountain whose rocks stand vertical or horizontal at one point may show them much inclined at others (its form will change to suit), and also, that as mountains are but fragments of the upper layers of

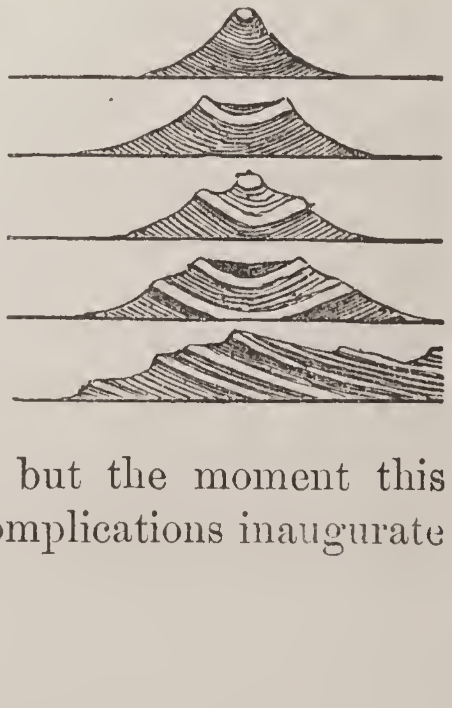
the earth's crust preserved from the general denudation and translation by lying lower than the rest, in hollows or synclinals as they are technically called, these synclinals as they rise above or sink below the average level or line of denudation will give up to destruction more or less of their contents. In other words, when a geologist traverses one of these geological basins lengthwise he finds the highest rocks in its deepest parts, and the lowest rocks in its shallowest or highest parts. The cross sections given below are arranged to show the coming in of higher and higher rocks as the basin sinks, and the consequent changes of form which the mountain or mountains undergo.

In every **Shallow synclinal** there is a high, narrow, flat-topped mountain, with precipices on both sides looking down upon the lowlands. Such is the structure of the Catskill, Towanda, Blossburg, and other mountains in the north, and the Cumberland mountains of Tennessee and Alabama. As the basins deepen, other higher sand-rocks



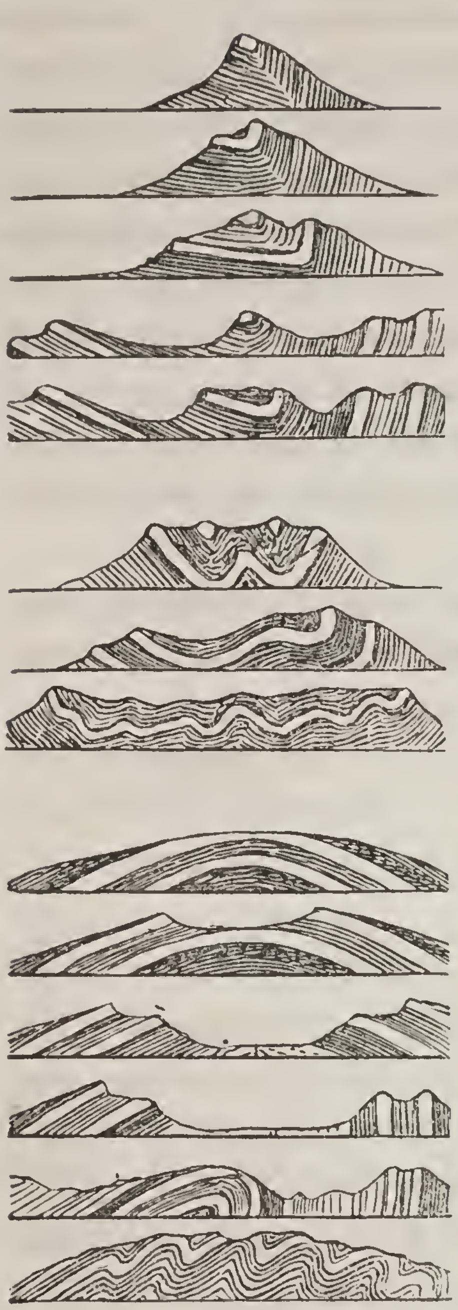
come in above, and double the precipices and slopes; finally the whole is cleft in two, and the drainage, after traversing the parted mountain often for many miles, breaks out sideways into the plain. It is evident that it was due to the direction of the original currents setting along the centre of the geological basin before the cutting developed the present mountain.

The **Sharp synclinal** shows this more clearly, with this difference, however, that its longitudinal central cutting is never a ravine, but always a valley. The hard rocks pass off in diverging crests terraced and gashed, inclosing one another, and giving place to mountain within mountain, in a series that has no limit but the number of hard beds in the system of formations. Their precise inclination with the horizon makes no essential difference in the action so long



as the synclinal remains a simple one; but the moment this becomes compound then all manner of complications inaugurate

themselves upon the surface and present a thousand puzzles to



the skill of the geologist, as in the fourth set, which more or less nearly represents the wrinkled compound synclinals of the anthracite coal region.

The **Anticlinal** structure is the reverse of the synclinal, and has its own infinite system of forms equally subordinated to the general laws of denudation, and in many respects curious inverted parodies of those above. In fact, as may be seen in the fifth and last set, the moment the huge back of an anticlinal mountain splits into two, we lose the anticlinal as a character of the mountain while it remains in the valley, until from the centre rises another mountain, to be again split lengthwise in its turn. In this case we represent the anticlinal as rising slowly, just as before we represented the synclinal as slowly sinking. The ridges on each side of a split anticlinal are called *monoclinal*, and are in fact the same as the ridges into which a parted synclinal mountain divides itself. Hence the forms are common to both. Much is here committed to the genius of the reader to study out and comprehend. But much can be learned by a careful study of the map of eastern Pennsylvania accompanying this Guide, where one may see the waved, zigzag, en-echelon outcrops of the great sand-rocks of the Palæozoic system sweeping round from the Hudson, in a series of groups to the Potomac; while to the southeast in a more irregular, intermitted belt, the primaries rise from beneath and separate them from the flat tertiary country of the sea-board.

The **first great sand-rock** of the Palæozoic system is the Potsdam sandstone. It spreads into Canada, crosses at the Saut Ste. Marie, and appears under the coal and limestone rocks of Iowa. It covers the northwest side of the Green mountains, the

highlands, the Easton, Reading and Conewago hills in Pennsylvania, and the Blue Ridge of the South (No. I.)

Over it are the vast limestone regions of the great Virginia valley, known as the Winchester, Cumberland, Lebanon, or Newburg valley further north—the central avenue and highway of agricultural wealth along the Atlantic mountain border. These are the Trenton and Black river limestones of New York, the limestones of Canada and Wisconsin, and the low limestones on the Mississippi. (No. II.)

Above these lie the Hudson river slates, the slates which form the northwestern half of the great valley just described, and reappear in many parts of the west. (No. III.)

This, which is the *Lower Silurian* system of the English, and made up of the first sand-rock, the first limestone and the first slate of the Palæozoic era, is characterized by peculiar metals and fossils, by lead and zinc, trilobites, and graptolites, and underlies the United States as a whole; is everywhere the floor; is sometimes, as in Western Pennsylvania and Virginia, three or four miles deep beneath the surface.

The **second great sand-rock** of the four, and the first that shows itself in an independent mountain form is the Medina sandstone. It is a vast precipitate of sand and pebble, the product of some ancient gulf stream or equatorial current, sweeping along the shores of then existing continents. Thin through New York, a mere knife edge of an outcrop along the Mohawk Valley, and scarcely apparent in the west, it begins to thicken as its eastern edge sweeps southward round the Catskill, and rises grandly into the air as the huge Shawangunk mountain of New Jersey, the Blue mountain of the Delaware Water Gap, the Kittatinny of Pennsylvania and the North mountain of Virginia. In all this eastern outcrop, where it rises steeply out of the ground, its edge is nearly two thousand feet thick, one gigantic triple plate of stone, and therefore forming a mountain line fifteen hundred feet high, cleft at intervals by gaps through which the waters of the inner country break out issuing to the coast. Further south it is thinner, but still forms formidable barriers, like the Peak mountain, the Clinch, the Walker mountain in Virginia and Tennessee. How it underlies the Western States, how rapidly it thins away and where its western knife edge lies, whether beneath Ohio and Kentucky or

beneath Illinois and Missouri, we can only guess by studying it through central Pennsylvania as it rises like a stricken whale again and again, as if to breathe, before it makes under the name of the Bald Eagle its last plunge beneath the Alleghany mountains, after which it is no more seen until it comes to the surface on the back of the Cincinnati axis.* All these sand-rocks thin rapidly westward, and not only grow thinner, but finer in their materials, less pebbly and more muddy as if we were getting off from the original shore and far into the original sea. But this second or "Levant" sandstone, as Rogers calls it, suffers another and characteristic alteration; its triple structure grows upon it; its two distinct and now thinner plates of massive flint being separated by a middle plate of several hundred feet of softer sandy shales and iron ore, form a double crested mountain or a mountain with a terrace on one side; a feature which distinguishes the mountains of this second sandstone from all others. Lead a geologist blindfold into the Kishicoquillas valley or into Morrison's Cove, and the moment his eyes are opened and his glances fall upon those magical terraces which Taylor, and others of the olden school, accepted as evidences of former inland lakes, he knows where he is in the order of the rocks, both how near the floor, and how near the coal. One glance at the inverted ship-keel knobs is sufficient.

I have said that Mr. Rogers calls this sandstone formation Levant. It follows his Matinal Limestone and Matinal Slates, and marks the sunrise of his Palæozoic day, the opening of the *Upper Silurian* era in American geology. But in the earlier nomenclature adopted in the Pennsylvania and Virginia surveys it was called No. IV, and is always so spoken of in common conversation by the members and students of those surveys. "Mountains of IV" are very numerous, being reiterated outcrops or reappearances and disappearances of the Medina sandstone as it rises and sinks in the Appalachian waves. Montour's Ridge, in the forks of the Susquehanna, is the back of such a wave, dying at both ends. The mountains of Union county, the Buffalo, White Deer, Deer Hole, Bald Eagle, Jacks, and Seven Mountains are all mountains of IV between the Susquehannah and the Juniata. These run on southward into Virginia as Tussey and

* The Louisville artesian well at a depth of 1596 feet strikes what may be the top of this rock 485 feet thick.—*Sill. Jour. March*, 1859.

Brush mountains. Between them and the eastern outcrops, or the great North mountain, which keeps on by itself into the south, are many separate canoe-shaped mountains like the Shade, the Black Log, Cove mountain, and the rest. Those of one group run into each other in curious zigzags, doubling like hares across a thousand streams, always bearing on their backs the red sandstone and red shale, with certain marls, and the rich fossiliferous iron ore (No. V) described in Chapter III, from which many of our best northern furnaces obtain their stock.

In the valleys which encircle these anticlinal mountains of No. IV and spread out into broad, well watered farming regions, full of hamlets, and traversed by large streams, crop out the rest of the Upper Silurian, and the first or lowest of the Devonian rocks —the Clinton, Niagara, and Hamilton groups of the New York geologists, the Meridial and Post-meridial rocks of Rogers's nomenclature, the fifth, sixth, seventh, eighth, and ninth of the original scale, a world of thin limestones, cement layers, black slates (with the carbonate iron ores of central Pennsylvania, central Kentucky and perhaps western Tennessee), coarse ragged flintstone, many colored clays, and olive argillaceous sands, thousands of feet in thickness, passing on upwards into red sandy shales and deep red sandstones ushering in our next and third division. It would require a volume to describe these various formations, making up four-fifths of all the valleys of the middle mountain region from New York to Alabama, spreading as limestones over all the surface of the west not covered by the coal, and constituting the west and southern half of New York, the west of Ohio and the larger portions of the other neighboring States. The Niagara river at the Falls plunges over the rocks of the lower part of this great group. Lake Erie and Lake Michigan are merely shallow valleys hollowed out in the middle rocks of this group and permanently submerged. The New York lakes are transverse valleys cut out of No. VIII. It is hardly to be disputed any longer that these are the principal rocks of middle New England, finding their lower level again beyond the Hudson, and descending beneath the coal of Rhode Island and Nova Scotia, but so changed that almost every recognizable feature is obliterated. In the interior however they are never to be mistaken, either by their relative arrangements, their characteristic aspects, or their wide-spread fossil shells,

which are the very same on the Delaware and Schuylkill as on the Houston and the Clinch.

It must not be omitted here, for this is its place, that there runs through these wide valleys a subordinate range of hills, the outcrop more or less distinguished of a peculiar but subordinate sand-rock called the Oriskany Sandstone No. VII, full of fossils, which when once seen can never be mistaken. Its origin was littoral or along a shallow shore, as Prof. Hall has lately shown by its groups of worn fossils. Its topographical exhibitions are extraordinary. The Pulpit Rocks of the Juniata are fragments of its horizontal layers. The rock is remarkable in many ways. It may be said never to vary its character, always a hard rugged cellular iron-stained chert. It is the point or plane of origination for a total change of life, one of the most striking of the phenomena of geology. A new creation begins here. It underlies a black slate deposit, an earlier attempt at making coal, and thus resembles the fourth or highest sand-rock, the base of the coal measures. Here in No. VII likewise we see a deposit of silex, thin, but of marvellous lateral extent, preceding a thin but equally

Specimens of the Juniata pulpit rocks of VII.

extensive and consistent deposit of carbon in clay. On the shore hills of Lake Erie this deposit of black slate actually contains a thin coal bed too thin to work indeed, and interrupted,

but no wise distinguishable from the coal beds which long after in the lapse of ages followed it. Such also is the case in western Kentucky. In the upper valley of the Delaware and Schuylkill near Stroudsburg and Orwigsburg and in many other places,

Specimens of the Juniata pulpit rocks of VII.

men have spent years, long lives in fact, and fortunes in digging vainly into this black slate for coal.

The **Third Great Sandstone** palæozoic formation No. X, inaugurates a new system of grouped mountains along its frequent outcroppings, which keep themselves always and everywhere apart from the groups of No. IV, never approaching them within three miles, and usually running in parallel lines with them at a variable distance of from ten to twenty miles, the interval being always filled up with the narrow knobs of the Oriskany, No. VII, and the broad, high, undulating, deeply ravined, and always cultivated hills of No. VIII. On the out or lower side of all these mountains of X runs an uneven terrace of the red sand of IX; and in those regions where the rocks stand vertical, this terrace rises to a separate summit, of equal height with the true summit and beautifully parallel with it; a narrow shallow crease divides the double summit, and then the long straight mountain with twin crests of wonderful evenness, but with this difference, that the outside one is red, and the inside one is white, runs along the map like the double beading of a picture frame. This is true of all that southeastern outcrop which encircles the anthracite coal basins, folding scrupulously

in and out around their long sharp points, crossing and recrossing the rivers and creeks, and presenting always outwardly or *from* the coal, its terraces of Old Red Sandstone. The same red and white frame is repeated around the Broad Top Coal Basin south of the Juniata. The Terrace mountain is its northern point, and western side, and Sidelong hill its eastern. The same surrounds the Cumberland coal region. This is the formation which constitutes so many of the long straight parallel ridges of central and southern Virginia, and the upper cliffs of the Catskill, Alleghany, and Cumberland mountains. Like the Medina sandstone last described, it is of immense thickness in the east and thins rapidly towards the west. Its Atlantic outcrop is over two thousand feet thick, hard and white, while its supporting red rocks, No. IX, are at least a mile in thickness; only the upper part of this red mass however forms the terrace or supplementary crest, except where they all lie nearly horizontal. This is the case at the Catskills. Here the pile ascends in steps three thousand feet, IX upon VIII, and X upon IX, and, on the top of all, the lower layers of XI. But as we follow this easternmost outcrop south through Virginia and Tennessee it slowly thins as if the original direction of the sediment was from the north and east. Yet more striking is the case when we step over to its inner outcrops. Around the Broad Top, and where it passes down beneath the Alleghany and the Great Savage it is still a mountain mass, but it rises again in Ohio and northern Pennsylvania from its underground journey so lean and changed as scarcely to be recognized. It is there a formation of greenish sandstone less than two hundred feet thick. The whole intermediate space, of course, it underlies; that is, all northern and western Pennsylvania, all western Virginia and the whole southern region of the Cumberland mountain; here it is as thin as in the Catskill region, but here as there helps to pile up the immense plateau, which narrowing as we go southward domineers with its lofty terminal crags the plains of Alabama.

Between this Third or Vespertine White Sandstone and the Fourth next to be described, lies but a single formation, the Vespertine Red Shales of No. XI. This softest of rocks—a pure red mud, once the mere ooze of the gently sloping shore of the quietest of seas, on the ridged wind-wave surfaces of which the rain showers of that ancient day have left their innumerable

pits, and the footsteps of unknown lacertian or batrachian tide-haunters are still plainly to be seen—forms a deep valley drained by a succession of short, straight, branchless creeks, which alternately run their red waters opposite ways from high and narrow sheds into the larger streams just where these are cutting through the gaps. One might travel along the string of valleys between these two mountains, as between two of the concentric walls of ancient Pasagarda, round and round the coal basins, without ever seeing a sign of civilization except some clearing where advantage has been taken of the rock-riffles in a gap to make a dam and build a saw-mill. There are but four places in Pennsylvania where this sharp straight catalogue of vales belies its nature and widens out into a plain of cultivation; namely, in the Locust valley, behind Tamaqua; in the Catawissa valley, still further north; in Pine Creek valley, west of the Broad mountain; and in Trough Creek valley, within the Terrace mountain, south of Huntingdon. Each of them is produced in the same way, that is, by a system of small parallel waves spreading out the rocks into a level floor. This red shale formation is three thousand feet thick at the Lehigh, Schuylkill, and Susquehanna rivers, and one thousand feet thick at the New river in southern Virginia. But it rapidly diminishes *across* the measures as we approach the Alleghany mountains. At Broad Top it is less than one thousand feet thick; at the Alleghany mountain it is scarcely two hundred, at Blairsville it is thirty feet, and in the Beaver river, lost entirely to view. It was peculiarly a shore deposit, rapidly suppressed as it advanced towards the deep sea, into the distant recesses of which only its finest white impalpable particles of fuller's earth were floated, mixed with carbonate of iron. It is, however, not to be regarded as a simple formation, for throughout its whole northern outcrop through Upper Pennsylvania, at Towanda, Blossburg, Ralston, Lockhaven, and the Portage Summit, it is a double or triple layer of red shale; and these layers are separated from each other, from fifty to two hundred feet, by greenish sandstones. It is an important key to the coal. Two principal events accompanied the deposit of this formation, which closing the Devonian era may be considered as the uppermost third member of the European Old Red sandstone, viz.: the embedment of the false coal measures, and the precipitation of the Ralston ore; the first

event opened, the latter closed its era. Of the former, the author has said what he knew at the time in his Manual of Coal[7] in 1856 and much more might now be said, but this is not the place. The Ralston or No. XI ore will find its place in the Fourth Chapter upon Carbonate ores.

The **Fourth Sand-rock** is the well-known No. XII or Great Conglomerate. It has its representative in the Millstone Grit beneath the European coal. It is the floor of the true coal measures, an immense preparatory outspread of sand and pebble-stones of every variety, but chiefly pure white quartz; and of every size, from the minute mustard seed and pepper corn to the hen's egg, and in the Susquehanna region even the ostrich egg. The evidence of the rolled origin of these pebbles is of course overwhelming;—from their shape, that of river cobble and brook stones, and of the constituent parts of ocean current banks and diluvial terraces;—from their constitution, without nuclei, diversified in elements and color, and bearing none of the marks of segregation;—from their local relation to one another, and to the tree stems and fuci packed up with them in the block, evidently a heterogeneous mass;—from their law of distribution, which reproduces all the facts we are familiar with in oceanic shingle beds, thickening in one direction and thinning in another, the local size of the pebbles agreeing with the local size of the bed, and therefore with the local turbulence of the current which rolled them along the shallow bottom. Everything in fact assures us against the notion of the concretionary origin of these pebbles. Nor is there any sufficient reason for selecting the pure white quartz pebbles from the rest, as segregations, for in all other respects they resemble the rest as rolled stones. It is characteristic of certain beds of this conglomerate, and that over wide areas, that they offer to the eye a certain *confluent* structure, while others are equally characterized by the universally distinct isolation of their pebbles, each one accented, as it were, while the other variety badly pronounces its constituent parts. This is very distinctly to be observed, for instance, in the Broad Top coal region, the lower coal conglomerate of which is confluent, while the upper or Cook rock, both here and along the Alleghany mountain, is finely discriminate.

It is certain that the origin of the conglomerate was oriental

[7] Lippincott and Co., Philadelphia.

It must have been produced along the shores of land which at the date of its deposit bounded the ocean, in which it was deposited, upon the east. It is of great thickness and very coarse towards the southeast, and grows thinner, finer, and more purely silicious the further it is traced northwestward. In the accompanying woodcut (Fig. 19) it is seen consisting principally of one horizontal plate, fragments of which tessellate at intervals the summit of the Towanda mountain in northern Pennsylvania. This plate is fifteen feet thick, occasionally subdivided into two, and always under and overlaid by thinner plates, the whole measuring less than a hundred feet. At Pottsville, on the contrary, the formation measures fourteen hundred feet. In middle Pennsylvania it varies from one to two hundred feet. We should say, at first sight, that the increase eastward was a local fact confined to the anthracite and semi-anthracite region. But in fact, what we call the Conglomerate Proper in that region is but one, and the lowermost, of several masses of sand and gravel thrown down at intervals upon each other, with coals and clays between; whereas the conglomerate of the west includes, perhaps, several of these masses, or what is left of them, each one having thinned out in that direction. At Pottsville, and through to Shamokin and Hazleton, there are four massive conglomerates above the Conglomerate Proper, each one from forty to eighty feet thick, and several massive sand-rocks besides of equal thickness, over these again. In Broad Top and the Cumberland region, these upper conglomerates and sand-rocks of "the coal measures" are also present, but all of them thin. Further west there is a certain declension, but its regularity or irregularity we have as yet no means of determining; that will be left as a legacy of research for the explorers of a future generation. This much, however, is very certain, and should excite our admiration as one of those curious coincidences which may well bear the name of providence, and be received as evidences of the forethought of benevolence, that we are indebted to this enormous local eastward thickening of the Conglomerate Proper and the conglomerate and sandstone beds above it, for our anthracite treasures. Had the rocks beneath the anthracite coal been the mere thin sheets of sand which they are to the westward, weakened still further by intercalations of clay and coal, their outcrop edges never could have withstood the rush

of denuding waters, and protected as they did the mineral fuel within their gigantic folds. What now are groups of long, slender, united, or closely parallel coal basins, would have been, but for this protection, wastes of red sandstone, or deep lakes in the olive shales of No. VIII, like those of the north. The comparatively little coal that has been hardly left in these small basins would then have gone the way of all that vast original deposit, the debris of which lies buried under the profoundest bottoms of the Atlantic, together with the immensely greater ruin of the formations underlying and preceding it. This will perhaps be made plain by the following map with which we

close this long but necessary digression from the subject-matter of the chapter, leaving the further description of the coal measures to which the Conglomerate belongs for the Chapter on the Carbonate ores.

In Woodstock county New Brunswick an immense bed of brown hematite ore is described by Gesner in his Fourth Annual Report, 1842, near the main road through Jackson Town. It is a triple bed subdivided by slate containing narrow seams of carbonate of lime thus: Clay slate —ore 28 feet—slate 250—ore 15—slate 100—ore 27—clay slate; dip nearly vertical, strike north-northeast for at least half a mile. The ore is distinctly stratified, compact, reddish-brown, frequently fibrous, and as if it had been once imperfectly crystallized, easily reduced, containing peroxide iron 78, water 12, clay 6, and yielding 40 to 50 per cent iron. Its discovery was

known in 1820 and claimed in 1836. The following letter contains matter of interest:

New Brunswick.

Bangor, *Maine*, *Sept.* 23*d*, 1852. MR. J. T HODGE: Dear Sir—I am this far on my return from the Woodstock New Brunswick Furnace, where I have been to assist in putting in repair and starting it.

You are probably aware that the company who own it have been troubled to make any but white hard and brittle iron from their ores. Before commencing with it I carried a sample of the ore and pig metal to Dr. C. T Jackson of Boston and had it analyzed. Its constituent parts contained:

Ore.		Hard White Iron (two samples.)		
Water,	12.05	Metallic iron,	A 83.276	B 85.254
Silica,	19.05	Metallic manganese,	15.500	14.410
Peroxide of iron,	43.00	Silicium,	.624	.336
Alumina,	4.01	Carbon,	.600	.364
Zinc,	4.02			
Oxide manganese,	17.05			

The iron is marked A and B. A was made with a hot furnace and B with a cold one, and the discrepancy in the product of .364 was owing to not separating the silex and carbon. Other samples of the ore and iron were analyzed by him before and found to contain **more manganese** than this—the ore 18.92 manganese, and the metallic iron 16.26. I am very certain that it is impossible to make any but white hard and brittle iron from the ore. I have used all the fluxes recommended by *Mr. Mushet* and other *English Iron Masters*, and can find no perceptible difference in the texture of the iron. Mr. Mushet recommended 12 to 18 hundred of limestone to the ton of metal produced. I tried it and even went as high as 28 hundred weight to the ton of metal and found no difference in the metal. The limestone would have cut the entire hearth away in a few days if we had continued it, from the appearance of what we did use. The ore needs no other flux besides what is contained in itself so far as I can discover. It makes a very liquid cinder and carries a bright tuyère put on what we may. I used 136 pounds decomposed primitive slate to 400 pounds of the ore, and could see nothing of it at the tuyères—35 pounds refractory sandstone to 300 pounds ore had no effect upon it, except to come before the tuyères in an unmelted state, and the ore consumed it there as readily as "*hot tallow*" would a ball of "*beeswax.*"

In fact it is **the most singular ore I ever saw.** The furnace carries a great burden of it, but its yield is not great. From four days' careful working and weighing all the ore and iron accurately I find it to yield $34\frac{33}{100}$ per cent of iron and manganese combined.

I send you some samples of curiously crystallized iron taken from a mass in the drain underneath the hearth. The last blast the iron cut through the bottom stone and run into the drain, from which I have broken these samples. It is a curiosity to me and supposing it may be to you, I send them.

If you have not noticed this furnace in the Railroad Journal, and if you find anything in this letter that you wish to insert, you may do it. Correcting such errors in my awkward writing as you think necessary if you please.

Yours truly, JONAS TOWER.

The metamorphism of the Lower Silurian formations so well proven in Pennsylvania and so obscure in New England, is well

made out in Canada. In that beautiful little résumé of North American geology presented by Logan and Hunt to the Exposition at Paris in 1853 we have the following:[8]

"The rocks of the East Canada basin have been overturned, plicated and dislocated into mountain chains which prolong the system of the Alleghanies, and sometimes attain the altitude of 4,500 feet; their rocks metamorphosed and crystallized by chemical action so that their fossils for the most part can no longer be recognized. These metamorphosed Hudson River (No. III) and Sillery rocks (a formation coming in between III and IV at the top of the Hudson river group) occupy a belt about 45 miles wide for 750 miles along the northwest edge of the valley of the upper limestones. But as the belt of metamorphic influence did not correspond with the range of plications of the rocks,[9] these last as they advance northward come at length to escape from it and exhibit their sedimentary fossil character undisguised. We are thus permitted to see the remarkable change of sedimentary rocks into chlorite-, mica- or talc-schists, or into feldspar-, amphibol- and epidote- rocks. Among the former are interstratified beds of serpentine, already traced for 150 miles, in company with beds of lime, dolomite, magnesite, amphibole and diallage. These changes seem to be occasioned not by the introduction of any new minerals, but by the reactions and chemical combinations of the matters existing mechanically mixed in the original sediments. The unchanged schists furnish on analysis 4 or 5 per cent of alkali, sufficient to constitute the feldspars and micas contained in the crystalline schists; the dolomites and magnesites always contain much silica and often oxide of chrome, which under the form of chromic iron characterize the serpentines of this region. The sedimentary origin of the serpentine is very evident and was probably a reaction between the silica and the carbonate of magnesia in presence of water, aided by a temperature more or less elevated. Bischof has shown that silex, even in its insoluble form, decomposes the carbonates of lime, magnesia and iron even at 100° C=212° Fahrenheit. Very silicious magnesites would furnish hydrated silicate of magnesia (serpentine) and dolomites, amphibole and diallage forms. Less silicious magnesites would give talcs and steatites, and less silicious dolomites the common mixed serpentine and lime. *Some* nacreous unctuous schists are not magnesian, but get their character from a micaceous mineral identical, at least in certain cases, with Guillemin's *pholerite*, a hydrated silicate of alumina. Observe, most of the metamorphic rocks are hydrates—serpentine, talc, chlorite, pholerite, diallage. Among the anhydrated silicates are pyroxene, orthose, epidote, and more rarely garnet, sphene, tourmaline.

"Approaching the northeast region it is easy to observe the gradual fading of the chloritic or nacreous aspect of the schists, taking their sedimentary character. Beyond the metamorphic but within the overturned limits, in the Sillery and Quebec rocks, many fissures are seen filled with a black, bituminous, fragile, sometimes mammillary matter, losing in a strong heat 20 per cent volatile hydrocarbons, leaving a coal powder burning with difficulty and leaving in its turn some tenths of one per cent ash, perhaps the condensed bitumen of the palæozoic rocks, volatilized by the previous commotions. In County Gaspé Upper Silurian unchanged contain fragments of and lie upon Lower Silurian metamorphosed; but in the southwest these fossils show the beginning of a metamorphism for themselves; in the valleys of the St. Francis and Lake Memphremagog the limestones become crystalline and micace-

[8] Esquisse géologique du Canada, etc., chapter vii., *freely* translated.

[9] A fact which destroys Rogers's theory of anticlinal metamorphism.

ous while their Upper Silurian and Devonian fossils can still be recognized both on surface specimens and in thin sections of the rock. **Vermont.**
To the southeast these crystalline limes are covered by mica schists more or less calcareous with macled schists, quartzites and garnet hornblendes all speaking of palæozoic metamorphism and penetrated by granites of a Devonian age. So that the metamorphic action and the undulating forces have been evidently prolonged to the very close of the palæozoic era.

"The crystalline rocks just described contain metallic veins which traverse both Lower and Upper Silurian rocks. One very ferruginous series of Hudson river schists give place in Cantons Bolton and Brôme to beds of magnetic and specular ore, disseminated in crystals, or oftener in little grains and pellets, in chlorite-slate with dolomite; beds from 2 to 6 yards wide of from 20 to 50 per cent ore, often contain minute quantities of titanic acid, which appears also crystallized as *sphene* in a cross vein in one of these iron ore beds, and in another as crystals of rutile and specular iron. Titanium has already been detected in the non-metamorphosed ferruginous shales. These iron ores are very abundant but not to be compared for importance with the Laurentian beds. They occur in many other localities. One remarkable bed of magnetic titaniferous ore is at Vaudreuil in la Beance, 17 yards wide in serpentine, granular, separable by the magnet, the pure magnetic part two-thirds of the mass, the other third *ilmenite* giving 48.60 titanic acid. The serpentines show disseminated chromic iron; one bed in Bolton 12 inches and one in Ham 14 inches thick, containing 46 to 50 per cent oxide chrome. It is also disseminated through the dolomites and magnesites. The minerals of copper occur in veins generally concordant with the strike and dip of the metamorphic rocks, and associated with Quebec dolomites.[1] At Leeds a ferruginous dolomite contains sulphuret of copper and specular iron ore."

No preparation could be better for a Cornwall mine or a Warwick mine in Pennsylvania; and these points are not omitted here, because they bear directly upon the theory of the origin of the brown hematites in the Silurian formations. Is it not strange that these Silurian crystalline ores of Canada should give place to the long range of Silurian brown hematites of New England, and these in turn to the similar crystalline ores of New Jersey, unless they are concordant deposits changed by local agencies?

In Vermont, the brown hematite mines follow the west foot of the Green mountains, in their proper place on the outcrop edge of the Lower Silurian limestone, here called by Dr. Emmons the Taconic. They are described in Mr. Adams' annual reports in an order from south to north, an order reversed in the following pages. The eastern shore of Lake Champlain is bounded by the Calciferous sandstone (Lower Silurian I, II), above which (to the east and dipping eastward under the Green mountain synclinal)

[1] Compare the Cornwall and Warwick copper in Pennsylvania.

is a belt of Hudson river slates (III) running the whole length of the State. East of this is a similar belt of magnesian slates (upper of III) east of which is the range of Upper Silurian sandstone (IV) called the Green mountain gneiss with coarse mica slate. East of this and running down the middle and like the rest the whole length of the State is a belt of talc slate; all east of which to the Connecticut river is an outspread of calcareo-mica slates. Were it not for the thoroughly metamorphic character of these rocks and the almost entire absence of legible fossils, and judging simply from the topographical expression of the surface, we would say that these are the representatives of the Upper Silurians (V, VI) still descending eastward, to pass under the great Devonian White mountains of New Hampshire, which are undoubtedly repeatedly synclinal, and wear all the features of a region of Portage, Chemung and Catskill (VIII, IX, X) rocks. This hypothetical view is curiously supported by the Bernardston fossils found at the extreme southeast corner of Vermont and which, although obscure and not yet studied out, look more like a group above the Helderberg limestone (VI) than like anything else. The principal objection to this view is the purely synclinal structure of the Green mountain plateau across Haverhill and Cummington in Massachusetts, which would naturally bring up the Hudson river formations in the valley of the Connecticut. This we know not to be the case, from the absence of any great limestone belt and the presence of coal measures in middle New England. Looking broadly over this interesting country no experienced topographical geologist can resist the conviction that the Lower Silurian belts in its western border go down under its middle region only to reappear in such spots as the granite quarries of Boston and Quincy, and along the shores of Maine,—even if it be necessary in order to make out the details of the plan to imagine faults along the western escarpment of the Connecticut valley. But if this plan in a rude sketch be true, then the eastern side of the Green mountains ought to show the Upper Silurian fossil ore of V in a line of exposures coextensive with the range; whereas we have but a few brown hematite beds in Plymouth, Sherburne etc. to show for it. The whole subject is as dark as any ever yet discussed by geologists.

In Highgate, **Franklin county**, and in Milton and Colchester,

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Chittenden county, along the lake shore, a few beds of ochreous brown hematite have been found. This is the belt of the calciferous sandrock.

In Moncton, Bristol, Huntingdon and Salisbury, **Addison county,** similar deposits have been found, of which that at the north end of Bristol, between New Haven and Moncton, was formerly worked to a considerable extent. It underlies the universal drift and, also a soft, moist, friable, iron-stained, calcareous clay rock "much resembling the limestone so frequently found with brown ore," and occurs between ridges of a peculiar greyish blue vitreous translucent quartz rock, which extends northerly into Moncton. The ore is much injured by manganese. A mile north of it, in Moncton, is an extensive old ore-digging under gravel (perhaps worth draining and opening anew) and the nearest rock is the quartz above mentioned. Half a mile west is another deposit. Another probably exists near the north end of Lake Dunmore in Salisbury.—All these localities are in the belt of the Hudson river slates.

The **Brandon deposit in Rutland county** belonging in 1845 to C. W. Conant, is said by Mr. Adams to be at a depth of 80 or 90 feet "quite free from admixture with the overlying drift, although mingled with yellow ochre and some of it finely comminuted. Large nodules are very common whose cavity is completely filled with water.[2] They have also been observed in the Chittenden deposits to be spoken of next. The Conant furnace in the village of Brandon uses this ore. The locality is one of great geological interest. With the iron ore is deposited oxide of manganese, kaolin or porcelain clay, and lignite brown coal containing multitudes of fossil fruit, figured and described by Prof. Hitchcock in *Silliman's Journal*, Jan. 7, 1853, and supposed by him and other distinguished geologists, to demonstrate the tertiary age of all the brown hematite beds referred to in these pages, and found distributed along a narrow belt of limestone country from Canada to Alabama. But this subject has been sufficiently discussed on pages 514, 515, 516 and 517 above. The company which works this ore bed and runs the furnace, was incorporated in 1851 with an ultimate capital of $150,000. It manufactures car-wheels, fire-brick, paints and

[2] This goes to show that the original form of the bed was that of carbonate of iron.

paper clay in Brandon. It has also a foundry and machine shop in Rutland, 300 yards from the railroad station.

The appendix to Thompson's Vermont says: "In the area above mentioned there have been sunk, principally for obtaining the iron ore, five shafts to depths varying from 100 to 130 feet. From these shafts, at depths of 80 or 90 feet, drifts have been sent off in various directions—by which the iron clay and coal have been passed through in various directions, and something has been learned respecting their relative position and extent. . . . The brown coal shows itself at the surface, and to the depth of 90 feet. It seems to descend obliquely by the sides of the kaolin in a columnar form about 20 feet wide and 14 thick." Prof. Hitchcock thinks it cannot have this form, but that of an oblique plate cut off by a fault. The report for 1853 of the agent, Jno. Howe, jr. Esq. says: "The operations have been mainly confined to a level 80 feet from the surface. . . . There have been raised during the year 3,984 tons of ore at a cost of \$1 13¼ per ton; . . 619 tons have been washed, at a cost of 37½ cents per ton for the washed ore. In addition to the saving of freight to the furnace on the washed ore—which amounts to at least half the expense of teaming at 28 cents per ton—we save large quantities of beautifully washed ochre and fine washings of ore;—from 12 to 15 shades of color—very durable, mixing easily with oil and flowing freely from the brush. The demand for manganese still continues limited. The furnace blew in 17th May, 1852. . . . The total amount of iron made in the two blasts of 121 days was 752 net tons, at a cost of \$19 64½ per ton." In his report of 1854, he says: "The lignite continues to be abundant and has been constantly used as a fuel in running the steam-engine." The black ore in the vicinity of the manganese bed we find very valuable to mix with the hematite, for the purpose of making the iron harder, and imparting to it stronger chilling properties. Raised 4,343 tons at a cost of \$1 33⅓ per ton; repairs, etc, increase the cost to \$1 53½. We have used the manganese to mix with our ore.[3]

In Pittsford, next south of Brandon, Rutland county, Granger's furnace (1845) already mentioned, stands on an extensive bed of brown hematite discovered in digging its foundations,

[3] Bulletin Amer. Iron Assoc. p. 77, 1857.

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beneath the drift gravel, in yellow ochre, with white clay, on limestone (Lower Silurian No. II). Furnace river exposes it. "Mr. Granger considers the proximity of limestone indispensable to success in discovering ore beds." The dip of the limestone in the southwest side of a hill 60 rods to the northeast looks like 50°–60° east, and here large quantities of ore were got, under the drift. Lumps are common near limestone 2 miles south. Brown ore and manganese were formerly worked beneath the drift on the river side 2 miles northeast, towards Crittenden.[3] The beautiful Pittston furnace 3 miles east of the railroad station enlarged in 1853, digs its ore on both sides of the stream, close by and also in Chittenden 2½ miles north of it, and mixes sometimes with it Lake Champlain magnetic ore.[4]

The Chittenden deposit in the same county, Rutland, east of Brandon and in the belt of talc slates alternating with quartz rocks (III, IV), three miles northeast of Granger's Furnace, not far from the west line of the town, was called in 1845 Mitchell's shaft, 60 feet deep, through clay ochres, white clay, manganese and brown hematite. Galleries a hundred feet long had been carried north and south, east and west, the north gallery striking a ferruginous limestone rock dipping 35° east and containing a large irregular vein of common quartz, and on it lie *conformably* clay ochres, white clay, fragments of iron ore and manganese and occasionally silicious sand. The south gallery cuts these, occasionally touching the hard rock and ending against a *solid bed of ore*,[5] from 2 to 4 yards thick, *reposing on the limestone* rock and underneath the ochreous strata above mentioned; an inch layer of yellow ochre parts the ore and rock. This is the first instance of the kind found in the long range of diggings from Bennington to the northeast part of Addison. Another shaft (Harrison's) strikes the same bed 80 feet further south and furnished in 1845 an abundance of pure rich ore. Much of the old disseminated ore was spoiled with manganese.[6] Granger's furnace made 40 to 45 per cent of iron out of the good ore. In 1845 it mixed New York magnetic ore but without perceptible

[3] Adams' report. [4] Bulletin Amer. Iron Assoc. 1857.

[5] Analysis—Peroxide iron 84.90, water 13.88, silica 0.75, alumina 0.47=metallic iron 58.66.

[6] The working of manganese was abandoned in 1844. Large quantities were obtained in the galleries and picked by hand from the crushed and washed ore.

advantage. The slag was stamped, washed and resmelted. Larned's forge on Furnace river also at one time mixed magnetic, but abandoned it for the pure ore which made excellent iron.

A "vein" of manganese, nearly 2 yards wide runs through a very loose arenaceous quartz rock, 80 rods northeast of the Mitchell ore-bed, associated with an impure silicious brown iron ore.[7] This also was in 1845 the only known instance of a vein or solid bed of manganese; at all other places it lies disseminated through iron ore, etc. One thing is therefore certain, that most of the surface deposits of brown manganesian iron ore beds are the mingled debris and decomposition of local veins or solid beds of the metals, originally thrown down not absolutely but yet so nearly together that their outcrops are near enough to allow of this subsequent chemico-mechanical intermixture. The rock in the immediate vicinity of the Mitchell mine is a calciferous sand-rock, and when the calc part is dissolved and washed off the sand with much of its manganese remains, while the white alumina or clay settles into pools with the iron ochres.

In Wallingford, two townships south of Brandon and higher up the Otter river valley, in the same belt of rocks, half a mile east of the South Village and Otter creek is a valuable bed of ore under a surface strewn with boulders of granular quartz (hardheads). The adit was carried through drift gravel 100 feet; sandy ferruginous limestone rock (dipping 60° east) another 100 feet; and then red and yellow ochres and white clay conformably interstratified and overlying the limestone 250 feet, to a bed of manganese and iron ore fragments, making very white, hard iron. This "black ore" yielded to Mr. Olmsted's analysis peroxide iron 71.30, peroxide manganese 12.93, water 12.50, silica 3.00, and a trace of alumina=metallic iron 49.34; and iron to manganese as 84½ to 15½, but this is no uniform proportion. The resulting pig metal analyzed as metallic iron 88.71, metallic manganese 11.28.

In North Dorset, where the belt enters **Bennington county** is a remarkable *vein* of disintegrated ochreous ore with a thin streak of solid ore through the middle, standing nearly perpendicular, running south 30° east, 3 feet wide, along through an

[7] Analysis—Peroxide iron 37.81, water 6.38, silica 55.81, and a trace of alumina.

Vermont.

argillaceous slightly ferruginous limestone ridge, which itself runs parallel to and at the foot of the Green mountain, and the strata of which dip only 12° east [in under the Green mountains]. Mr. Curtis opened the vein at the north end of the hill a few rods east of his furnace and followed it in, 150 feet, where it was 100 feet beneath the crest of the hill; he has detected it also half a mile further south. The whole vein is decomposed to ochre with the exception of the central streak of solid ore, and Mr. Adams admired it as the only true vein he knew of in this limestone formation, and suspected that it had been a vein of red specular oxide. The fact probably is that the central plate of solid ore instead of being a relic, is an incipient crystallization of the solid vein; and as the limestone is divided up into rhomboids by two systems of joints with the bed-planes, this perhaps has been a profound shrinkage fissure filled with hydrated peroxide of iron by drainage waters. The Dorset furnace is supplied, when it works, with ore from the East Dorset ore beds, 3 miles further south, where the ore is ochreous and fine and associated with white clay, and 3 tons make a ton of iron.

In Bennington, near the southwest corner of Vermont and in the northeast corner of the town, on the same limestone belt, a new ore bed was found in 1845 in addition to those near the furnace. The furnace bed is described by Professor Dewey as some rods wide and only separated by a thin partition of clay, often not half an inch thick, from a bed of manganese.[8] Here is said to have occurred the following curious experience in iron smelting. About 1820, when Mr. Trenner worked the furnace, thinking that the magnesian ore was purer iron ore, he charged the furnace with it. At the first run however the whole casting house was in a blaze and the furnace had to be extensively cleared out. Mr. Adams gives the correct explanation by referring to the common experiment of obtaining a jar full of oxygen gas by heating the black oxide of manganese and then plunging a red-hot wire into it, the iron will burn with great fury.

[8] However absurd such a description seems to be under any of the accepted wash theories, it is strikingly illustrative of the decomposition of two sub- and super-incumbent massive strata of rocks one of which was originally highly calco-ferruginous and the other as highly calco-manganesian.

In **Massachusetts,** in the northeast corner of Bernardston running into the southeast corner of Vermont, is a series of rocks affording slate for roofing, probably Hudson river No. III, and on them (whether conformably or not the false cleavage of the slates makes it hard to tell, but probably non-conformably) lie nearly level layers of fossiliferous limestone and a bed of iron ore two or three feet thick. The fossils are imperfect but numerous and look like an Upper Helderberg or Lower Devonian group. If so this ore will correspond with the ore of middle Kentucky, and of Perry and Juniata counties in middle Pennsylvania.

Taking up the Lower Silurian limestone belt where it enters from Vermont the **northwest corner** of Massachusetts, passing down into the northwest corner of Connecticut and spreading over a strip of eastern New York next the New England line, we find many valuable beds of brown hematite feeding furnaces which make the celebrated "Salisbury brand" iron, in Lenox, Richmond, West Stockbridge, and Salisbury Connecticut. None of these beds are described by the Massachusetts State Survey, but resemble those of Vermont. As in the beds at Bennington, Vermont, manganese abounds, so it is a constant constituent in all these more southern ores; with the ochres of iron, solid brown hematite, some red oxide and argillaceous oxide.

The North Adams furnace (B 8) on Hoosic river mixes Adams, Lanesboro', Richmond and Amenia ore. The first is 2½ miles southwest, the second 14 south of the middle of the town. Cheshire furnace (B 9) has its own banks of 50 per cent ore within half a mile east and west of it. Briggs's furnace (B 10) in Lanesboro' village uses Lanesboro' ore 3½ miles west of it. Hodge calls this Lanesboro' furnace. Lenox furnace (B 11) gets its own 32 per cent ore from 4 miles west, but some 60 per cent from the West Stockbridge mines, which feed also the Hudson Anthracite furnaces A 11, 12. The Stockbridge furnaces, one anthracite, (A 3 and B 12) get ore from the West Stockbridge and Richmond banks 6 miles west. Richmond furnace (B 13) has its own banks and owns the West Stockbridge banks also. Vandeusenville furnace (B 14) uses Richmond ore 10 miles north, and West Stockbridge 7½ miles north. The Berkshire anthra-

Massachusetts.

cite furnaces (A 1, 2) uses Richmond ore, Shaker ore from the Shaker depot on the Western railroad, but chiefly West Pittsfield ore, all from five to seven miles north of the stacks. From some of these deposits, says Mr. Silas Burt,[6] over 100,000 tons of washed ore have been taken out without showing any signs of exhaustion. Dr. Hitchcock however spoke in 1833 of the Bennington deposits as nearly exhausted.

In **Connecticut**—Beckley, Forbes and Buena Vista furnaces (B 15, 16, 18) mix Salisbury, Oldhill and Davis ores. Scovill furnace (B 17) in South Canaan uses Davis ore 8 miles west, Oldhill, and its own bank 10 miles west. Cornwall furnace (B 19) uses Amenia ore 12 miles west with Salisbury ore 10 miles northwest and roasted it at one time by turning its spare gas through the stacks in the yard. Mount Riga furnace (B 20) uses Oldhill ore 1½ miles southeast of Dagon's furnace; this is a huge open quarry across which a high bridge carries the main Millerton-Hartford road; also Davis ore 1½ miles east of Oldhill diggings near Lakeville or Furnace village; also Dagon's ore. Chapinville furnace (B 23) uses Oldhill ore. So does Limerock (B 24), a very old iron site, where bloomaries worked up Oldhill ore 120 years ago. This ore fed also the old furnace at the Falls village, now torn down, and the still older Lakeville furnace, also demolished, which made shot and shell for the British troops in revolutionary times. Weed's furnace (B 25) uses Salisbury, Amenia and Palmer ore, the last 500 yards west of Amenia station in New York, and also from Adams's and Gridley's ore banks close together. Kent furnace (B 27) has its mines 6 miles southeast and sometimes uses Kent and Amenia ore. Macedonia furnace (B 28) in Kent, uses Amenia ore, 10 or 12 miles west by road, but only 8 direct. Sharon station anthracite furnace (A 4) uses the Megat ore, with some from the Amenia bank, three miles to the north, and some from the Salisbury banks to the northeast. The **Megat banks** are within stone's throw of the furnace: an open quarry of loam, sand, blue clay, and hematite ore balls, shells, pipes, and mammillary masses, thrown down irregularly on one another, in perpetually variable quantities and qualities, replacing each other in level layers,

[6] Correspondence of secretary A. I. Assoc.

horsebacks, lens-shaped masses, with every appearance of tumultuous local deposition. No bottom has been got at 25 feet; but rock walls the quarry on one side. The surface, before breaking ground, was as irregular as the ore masses. The **Amenia ore** is said to lie along a vertical fissure 30 feet wide, more or less, for half a mile, north and south, then bending suddenly and running straight again for a mile, in the direction of several ore beds several miles distant to the southwest. Ore has been taken out in this pit 100 feet beneath the surface, and no bottom.[1]

Salisbury Ore-hill is thus described by Shephard in his report of 1837. Two miles west of Furnace pond; open quarries over several acres; 20 or 25 feet deep, including Big drain, Mammoth, Cornstalk, Blodget and Kelsey's, Brook and Walker's pits each explored by a separate company. The first named raised 1,000 tons between April and July of 1836, paying a leave rent of $\$1\frac{1}{4}$, and carting for a shilling ($\$0.12\frac{1}{2}$) a mile. The average of the bed 40 years preceding had been 5,000 per annum. It was dug through at its western end. At that time it fed Chapin's, Salisbury Company, Canfield's, Limerock, two Cornwall, and Ancram furnaces. Average yield 40 to 50 per cent iron, used chiefly for anchors, axles, tires, etc.

Chatfield's bed is only quarter of a mile from the Salisbury Orehill, southeast, and 100 feet lower; lies north and south, 40 or 50 feet wide and 25 or 30 deep; both bed and rock dipping 50° east; the rock decomposed for 10 feet in from the bed; the bed at the south end shutting in to 10 feet wide (going down) and wheeling round with a south dip towards an old pit in which the dip was southwesterly, and so on in the direction of Orehill. Here we have all the features of a dying anticlinal, with a regularly stratified hydrated peroxidized original deposit of iron. The Tertiary theory is clearly inadmissible. In 1835 800 tons were raised. The fibrous varieties here abound.

Davis' bed in Salisbury is three miles northeast of Orehill, the ore being found in grey fuller's earth. Scovil's and Chapin's beds in North Salisbury are a mile apart, and were abandoned from difficulty of draining for eight years previous to 1837 but are now wrought.

Indian pond ore-bed 60 rods east of the pond and 40 to 50

[1] Bulletin A. Iron Assoc. 1857.

Connecticut.

feet above it at the base of a high ridge of mica slate, is distinctly stratified with the rock, dipping 45° east, and covered with drift gravel. The ore becomes lean sometimes and the better portions have to be pursued; 2,000 tons per annum taken out; iron less malleable than Salisbury. (Shephard 1837.)

Kent ore-bed was formerly very important, but was most improvidently mined. It lies on the west slope of a low mountain, 200 feet high and 3 miles long, and near its base. The following section given by Shephard is difficult to understand. B is the ore bed consisting of a number of nearly parallel beds parallel with a foot wall of decomposed micaceous gneiss rock (A) dipping 60° to 80° east, apparently under the ore, and covered with drift gravel (d). The decomposed mass is called by the diggers fuller's earth. The different ore strata beginning at the

west were called (a) drain vein, b chocolate vein, c blue swamp, d anvil ledge, the first two being each about 12 feet thick. In 1837 the hanging wall impended fearfully, 50 or 60 feet high, and terrified men from further working the mine. It consisted of decomposing quartz mica slate with same dip as before (80°) but in the opposite direction *west*, as if again under the bed, back of which were alternating strata of quartz, decomposing gneiss and quartz mica slate, dipping 20° east *nonconformably* says Shephard *resting upon the basset edges of the last.* Then came the artificial pond on the high ground, periodically every day let off by a sluice to wash out the mine. Beyond which (east) appears massive granitic, sometimes hornblendic gneiss dipping 80° to 85° west. The ore after Shephard's report was reopened half a mile along its strike towards the north and still yields ore. The anvil ledge requires notice; being an iron breccia of quartz and ferruginous jasper fragments cemented by limonite (hydrated peroxide iron), with cavities lined with minute quartz crystals. It is extremely abundant but makes a poor iron on account of the silica.

Into **Eastern New York** the Lower Silurian No. II limestone belt passes with its brown hematite ores. **Copake** furnace (B 29) has a large open mine at the Harlem railroad station in Copake, the ore of which runs from 40 to 45 per cent. Limestone, says Mather, crops out a little west of the Copake bed and mica slate not far to the east. An ore bed was opened before 1837 two or three miles south of it, and two miles north of Boston Corners. Northeast furnace (B 30) has its ore beds within 30 rods. Benedict's furnace uses Salisbury ore, these famous diggings being but 2½ miles distant to the east. **Amenia** furnace at Wasaic station has a celebrated mine, which feeds not only this and some of those already mentioned but some anthracite furnaces also. Dover furnace (B 33) uses principally Amenia ore, a little also from Quaker hill 5 miles southeast, and Clove-hill 7 miles west. White's Dover (B 34) uses the Foss bank ore 2 miles southwest of it and one mile west of the railway. Beekman's furnace (B 35) has its own banks in Unionvale 2 miles north which yield 40 to 50 per cent ore. Fishkill furnace (B 36) and the Poughkeepsie anthracite stacks (A 13, 14) are fed from the Hopewell ore bed. Bull's Falls anthracite furnace (A 5) mixes Quaker hill ore 4 miles west, with Kent ore 3½ miles east, the Kent has 45 per cent iron, the Amenia makes but one ton out of 2½ of ore.[2]

The **Columbia and Dutchess County** limonites or brown hematite ore deposits, says Mather, are numerous and easily wrought, pulverulent and compact mixed, mammillary, botryoidal, spongiform, stalactitic, some with hemispherical and some with acicular terminations, others like bunches of pendant moss. The mines yielded in 1838 about 20,000 tons per annum, worth from $1 50 to $2 50 per ton, feeding 10 furnaces within 12 miles of Amenia, not including Ancram and Hopewell furnaces. The geological position of the ore beds is very constant. Most of the beds Mather examined are at the junction of mica or talcose slate with the grey and white limestone, which crops out generally on their west side, the mica or talc on the east, both dipping at an angle from 20° to 60° east-southeast.[3] This would make the mica slates above the ore and the limestones below it.

[2] Bulletin A. Iron Ass. 1857.

[3] Report, Assembly Doc. No. 200, page 182.

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The ore would then have been at the junction of metamorphosed Lower Silurian formations II and III.

The **Amenia bed** in the northwest part of the town presents, as described by Dr. Beck, all the varieties observed at Salisbury and other localities, occurring in the form of very beautiful stalactites, with the same high polish, or black sooty matter on the inner surface of the nodules, which frequently show a light brown fibrous structure. A beautifully radiated stalactite gave specific gravity 3.828 and on calcination lost 13.50, Peroxide iron 82.90, silica and alumina 3.60, a trace of ox. manganese. The bed was said in 1841 to yield 5,000 tons per annum. The Indian pond bed 2½ miles northeast of it, and the Squabblehole bed 2 miles south-southwest of it, may be its prolongations.[4] Mather estimated the Amenia bed at 100 yards broad, 1,000 yards long and 15 yards deep (in one place excavated 45 feet), talc slate cropping out a few rods east and white limestone a few rods west; but it is probably only about 30 feet broad and has been sunk upon for a hundred feet.

Foss ore-bed in Dover town 1½ miles west-southwest from the furnace lies in a valley between two mountain spurs and is particularly interesting according to Dr. Beck for "showing the association of the hematite with the mica slate," here in thick strata and garnetiferous. The bed is not of the first class; the ore is in large masses, does not exhibit beautiful imitative forms, is hard to crush, and contains much foreign matter.[5]

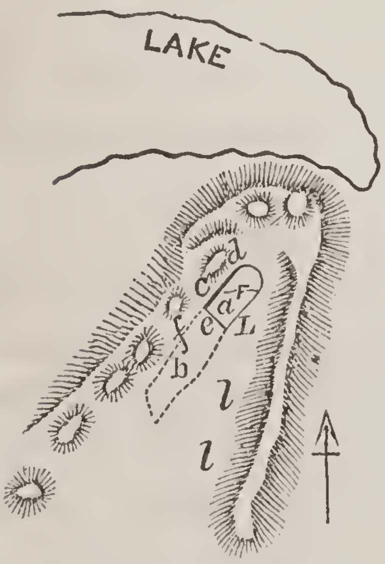
Clove ore-bed in the southwestern part of Union vale is an open excavation like the rest, with much fine ochery ore, considered valuable in the furnace, and has occasional bluish masses like specular oxide which on examination consist of minute crystals of oxide of manganese with a high metallic lustre. Here also occurs that rare mineral *gibbsite.* One analysis gives peroxide iron 80.27, water 11.66, insoluble 7.43.[6] The Clove bed is bounded on the east (*not west*) by limestone and is chiefly fibrous brown hematite.[7]

Fishkill ore-bed three miles northeast of Hopewell village occurs on a coarse gravel hill and contains every variety of ore from compact brown to yellow ochre; the brown ore usually in hollow nodules, sometimes containing beautiful stalactites and

[4] Beck's Report, page 33.
[5] Beck's Report, page 32.
[6] Beck's Report, page 31.
[7] Mather's Report.

their lining of manganese. The bed occurs at the junction of the grey-white limestone with mica and talc slate.[8]

In Mr. Hodge's report[9] on the Fishkill mine in 1832 he says: The hematite ores here, as elsewhere, rest against the ledges of limestone. The connection is so universal it may almost be regarded as essential. The ridges of this rock are hence the best guides for tracing the course of the ores. The usual direction of the ridges and ore beds is north and south. The latter sometimes, however, spread out in very irregular shapes, and to considerable distance from the limestone, as the Salisbury bed. At the F. bed some confusion arises from there being two ridges of limestone—one running nearly north and south, the other northeast and southwest, the ore bed included between them. The accompanying plan represents the position of these. The two ridges of limestone are seen one on each side the ore; that on the west is much broken and low. That on the east is more regular and the ore is opened in close proximity to it. In the deeper workings a narrow belt of silicious slate and quartz only separates the lowest layer of ore from the limestone, which dips beneath it. At the point *a* the workmen are now



excavating a high breast of ore in the direction towards *b*. From the bottom *a* to the edge above (*c*) the height is fifty-eight feet. The layers of ore vary in thickness in this wall. At *d*, commencing at the bottom, there is a thickness of 14 feet very rich in ore, then a barren layer of clays and ochres of a few feet and above some six feet more of ore—above this clays and ochres to the surface. The ore beds incline in the direction of the arrow, so that they must be worked deeper and deeper towards the west. At *c* a section presents less ore; at *e* there is 14 feet of excellent ore above, then a varying body of clay etc., of from 10 to 16 feet, and below this ore again six feet and more in thickness. At *f* in some old shallow pits on a higher level there are other still higher belts of ore of very promising appearance. At *b* about

[8] Beck's Report, page 31. [9] To Joseph Tuckerman, Esq.—in MSS.

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100 feet from the breast at e the ore is found in several shallow pits, which proves its extension for this distance at least. But there are many shallow workings, from which ore was evidently taken out at some former time, that extend full six hundred feet from e southwest, and they widen out beyond the dimensions of the excavation at a, which is about 100 feet wide. These workings seem to indicate that the course of the bed is southwest. I should strongly recommend sinking some shafts ahead in this direction, and opening the beds wherever they are found richest. By thus keeping some known points in advance to which mining operations can be directed in case the one now worked at a should not continue to yield alike, the mine is always producing, and no want of confidence is entertained of its continuing to do so. Wherever the bed is worked deep, it should be made to drain to the pump in a. The discovery of the ore by Delany to the southwest is additional evidence of the bed running this way. There is enough ore to supply the present demand for this ore of say 8,000 tons per annum, for many years to come, without attempting to go deeper than the present lowest workings.

A topographical geologist will at once decide upon the dying anticlinal structure of this exposure. The ores are under the limestone formation No. II, which folds over them and carries them down beneath the lake.

Prescott's ore-bed is one and a half miles north of the Columbia turnpike in Hillsdale, bounded west by limestone, was not much worked before 1822 when Prescott began the manufacture of yellow ochre here. The nodules of brown hematite increases and the ochre decreases as it descends. (Mather.)

Westchester Iron Company's mine in the southeast corner of Columbia county is described by Hodge in the company's report for 1856, as three and a half miles from the Harlem railroad, covering a large extent of ground, with an open cut across a little ridge laying bare irregular layers of clays, sands and ore; in a tunnel from this cut, 150 feet north, ore is seen as a solid wall. Mr. Bushnell reports the ore in similar abundance at McClellan's, a mile southwest of the Reynolds cut.[1]

[1] All the above details are from the Bulletin of the Amer. Iron Assoc. 1857.

Orange county. In Cornwall, 2½ miles west of Canterbury is Thomas Townsend's hematite ore bed, the ore in powder, mixed with balls, between the limestone No. II and the grit rock No. I, the rocks in contact being decomposed and mixed with the powdered ore. "This stratum of limestone and hematite ore can be traced across the town into Monroe until we reach the magnetic oxides already noticed. It is seen a quarter of a mile north of the Clove mine and at many places intermediate between this and the Townsend mine in Cornwall. The distance is full ten miles. Hematite is also found along the whole western side of Bellvale mountain and in places along the Warwick valley to the New Jersey line."[2]

Pochunk mine (Col. Joseph Edsall's) in northern New Jersey, three miles northeast of Hamburg and one south of Smithville is immediately on the line of the mountain gneiss and white metamorphic limestone at the foot of the Pochunk mountain. The ore is a mass of concretions, in variegated clays, massive and cellular, sometimes fibrous, mammillary, botryoidal, often hard enough to require blasting. The workings are dry and the feldspar gneiss rocks alongside are decomposed containing much *plumbago* in powder; clearly indicating (says Rogers) that the dissolution of the crystalline limestone has been in part at least the cause of this large accumulation of ore. This ore opened about 1835 fed Hamburg furnace and was hauled 12 miles to Clinton furnace and still further to Ryerson's furnace near Pompton. But this was fifteen years ago, and being a very irregular deposit it is now apparently almost exhausted. Another deposit is described by Rogers in 1840 two miles east of Hamburg above Sand and Mud pond forks between the primary base of Wallkill mountain and a small knob of gneiss a little west of it and near the northern termination of a belt of white crystalline limestone which must have occupied this little valley once and probably gave origin to the ore. In 1840 the mine was 140 feet long, 40 wide and 40 deep, and was discovered by sinking a well. No doubt many a valuable deposit lies concealed along the limestone Lower Silurian valley of northern New Jersey, beneath the gravel drift. It has been found between Belvedere and

[2] W. Horton's report to W. W. Mather, appendix (B) State Doc. No. 275, page 165.

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Easton on the Delaware, as at Foul Rift, and in the form of pipe ore.

Simpson mine near Smithville is a small depot of specular ore in the limestone; and boulders of *brown hematite* and specular are abundant between Pochunk and Simpson mines and Hamburg. No ore is seen in a southwest direction until one reaches the franklinite and magnetic beds near Franklin furnace; and none further on until we reach the primary Tar and Andover mines within a mile and a half of Andover, mixtures of magnetic and sulphuret ores.

Anderson mine has been described on page 427. Kitchell says that it is rather a red oxide (true hematite) than a magnetic bank, and that during the eight years' superintendence of Mr. George more than 120,000 tons were sent away. It would not be mentioned again in this chapter but for the occurrence, among Mr. Hewitt's list of minerals which are here mined, of specimens from masses of *limonite*, from shallow excavations northeast of the great mine, containing amorphous malachite and azurite; also powdery limonite in very large masses, with malachite incrustations on jasparoid hematite, massive pyrites honeycombed by oxidation, etc. etc. with galena (sulphuret of lead) in some abundance, generally finely granular and incrusted and mixed with a yellow carbonate of lead. Copper pyrites also occurs in the Andover mines. It is remarkable that with the abundance of various forms of minerals here there should be so little to be said about *limonite* (brown hematite) as a workable ore. *Edsall mine* in the Wallkill mountain (ferruginous) gneiss, four miles west of Canisteer pond and three northeast of Upper Hamburg was worked for a number of years for Hamburg furnace. (The Ogden Wallkill mine 2 to 30 feet thick and 50 feet deep; the Vulcan veins 9 and 10 feet thick; the Sherman Sparta in several openings from 3 to 10 feet thick are probably magnetic). It is curious that the celebrated Hurdtown apatite (phosphate of lime) mine, with its pyrites, magnetic pyrites, magnetic iron, etc. etc., shows no limonite or brown hematite; neither do the majority of these primary veins, although they contain an abundance of pyrites. The soda, magnesia and lime of the Lower Silurian waters seem to have been necessary for its production.

Osborn mine, one of the four principal Mount Olive range of mines, three miles from Stanhope on the road to Mount Olive,

was opened at its discovery in 1848 and is one of the few magnetic ore beds mixed with considerable *limonite* and decomposed feldspar. The vein dips 45° southeast, is 10 to 15 feet wide and strikes northeast through low ground and it must be steam drained. *Hilt's mine*, also magnetic, contains also some *limonite*. It lies a half mile to the east of the Osborn and is a seam 5 or 6 feet wide dipping 75° southeast. Like the last, much of its bulk consists of altered feldspar and limonite, somewhat polaric, masses of white altered feldspar, sometimes associated with quartz and decomposed hornblende appear in great quantities among the rubbish. This recalls to mind the beds of *Kaolin* in the Brandon and other mines in New England and New York and makes the genesis of those brown hematites from magnetic ore, or vice versa the genesis of these magnetic ores from brown hematite look probable. *Drake's mine*, two miles southwest of Hilt's, shows the decomposed feldspar stained with *limonite*. It was discovered in 1854, 5 feet thick, dipping 45° southeast, opened 18 feet deep for 100 feet, in 1856. *Stevens' mine*, a continuation of Drake's, a quarter of a mile southwest of it, discovered in 1848, dipping 45° southeast, 90 feet long, 4 feet wide in the middle, 2 at the west and 1 at the east end, gets too pyritous to work 15 to 20 feet down, but consists until then principally of polar, frangible, powdery, decomposed, magnetic ore mixed with much *limonite* and feldspar. Some pieces are heavy and rich and others the most powerful magnets. The hanging wall is fine-grained feldspar and magnetite, the foot wall is altered feldspar containing much magnetite and much stained with limonite. Between Stevens' and Drake's mines are a number of other openings on the same vein. In one of these similar surface ore is found; but below, the ore is dense and heavy and the pyrites uniformly distributed in small strings and bunches. "On attentive examination of the ores of this Mount Olive district, there appears to be a great similarity in character among them. Thus they all retain indications of having been subjected to intense chemical action, being impregnated with limonite and highly altered feldspar. In the small opening near Stevens' mine we see distinctly that the whole seam has formerly been loaded with pyrites which for a few feet below the surface . . . has been removed by oxidation and a quantity of limonite only left to indicate its former existence. Now considering the large

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quantity of limonite found associated with all the other ores of this section, analogy leads us irresistibly to the supposition that in all probability the structure of the other seams is the same, and that after descending below the point which is probably at or about the water level of the locality they will be found to be pyritous to a greater or less degree." (Kitchell, page 179.)

Marsh's mine on Schooley's mountain Washington township Morris county, 500 yards from the Heath House, is a hard amorphous magnetite vein much stained with limonite. Dickenson's mine 400 yards east of it is similar but shows more hornblende.

The eight magnetic Ringwood mines of Passaic county are too pure to show much limonite decomposition, but contain decomposed feldspar. Most of them as described by Kitchell are not only sedimentary beds, but double beds, with rock partings. Some contain phosphate of lime; but the whole mass is so composed as not to furnish limonite. Iron pyrites seems rare.

The nine principal magnetic Mount Hope mines, 20 miles southwest of the Ringwood group, are still older and more important, four of them in Mount Hope, three in Hickory Hill, and two in Mount Teabo. "The old Openwork, jugular, or Mount Hope mine is distinctly seen to be stratified, says Mr. Wurtz, at the northeast extremity of the open cut; and the strata are parallel with the gneiss strata on each side, all standing nearly vertical, and the foot wall covered with vertical furrows or marks of sliding. The hanging wall is highly hornblendic and schistose with interposing layers of brown mica; the foot wall contains much decomposed feldspar and some magnetic iron. Phosphate of lime occurs. Bed divided by a rock parting, or horse, and the ores differ in the upper and lower bed thus made. No limonite is mentioned in connection with any of these openings. The Mount Hope tunnel, driven in from the southeast foot of the hill, 500 feet in 1855, to cut the jugular vein, cuts three other seams, first one from 2 to 3 feet thick, then the Brannin vein 3 to 4 feet thick, thirdly the Teabo (?) vein 5 or 6 feet thick. The rock at the entrance is a coarse schistose quartz-feldspar, the latter much decomposed. The first ore is granular crumbly mixed with very much altered apatite (phos. lime), hanging wall decomposed feldspar gneiss *mixed with much limonite*, foot wall same but more decomposed. Second ore, laminated, much apatite, with slickenside fissures, hanging wall highly schistose black mica and white feldspar, foot wall coarse schist feldspar and quartz with particles of magnetic iron. Rock 330 feet in, large granular schist feldspar quartz with magnetic iron dispersed. Rock 430 feet in, schist of green feldspar and white quartz with particles of magnetic iron and seams of pyrites. Third ore hard, fine, quartzose cleft, often pyritous, hanging wall like last, but finer and pyritous, foot wall same with seams of *red hematite and pyrites.*

Thus Limonite is a very subordinate and accidental occurrence in these magnetic veins. At Clay mine it occurs in honeycomb quartz rock filling the cavities. Half a mile southeast of the Mount Hope mine is a deposit of *bog* limonite however, covering about 15 acres, one or two feet deep among pebbles, with much manganese, less phosphate of lime, no sulphur, no lime and no magnesia. Another such bog is seen a mile north of Dover and others nearer town. The Elizabeth vein on Mount Teabo is magnetic but deserves mention here as illustrating the disturbance of the region, as its average dip of 72° (6 feet thick) changes every eight or ten feet going

down, over a series of horizontal undulations. The Teabo mine is 200 feet deep. The Allen bed is double (rock parting) and then single 22 feet thick, the hanging rock being a curious mixture of magnetic iron and hornblende, the parting of magnetic iron and feldspar and the foot wall of green feldspar with black hornblende and magnetic iron; but no limonite is anywhere mentioned, except as staining the ore in one of the side workings. Here occur those curious and interesting masses of true conglomerate composed of *sharply angular masses* and also nodules of crystalline granular magnetic iron, *evidently fragments of a formerly existing formation*, which has been broken into pieces by violence, *cemented together by a white opaque crystalline carbonate of iron* (chalybite), so purely white and free from stain, so pearly, as to have been mistaken for pearlspar, or dolomite. Its beautiful rhombohedrons line cavities and show their characteristic curved faces. It occurs sometimes associated with *large masses of pulverulent limonite*, probably the product of its own decomposition, sometimes also with crystals of pyrites of the metamorphosis of which it may itself be a product. (Kitchell.)

Mount Pleasant mine is magnetic and curious for its five faults or downthrows, diagrams of which are given in Kitchell's report, p. 203, important additions to American structural geology, in regions out of the anthracite basins of Pennsylvania. But neither here nor in the Huff is any mention made of limonite. The Irondale and Hubbard mines are remarkable for dipping only 30°. The Stirling 16 foot bed is parted by rock into numerous small beds. These mines with the Corwin, Mellan, Byram, Brotherton, Dickenson, all show more or less phosphate of lime (apatite) with their magnetic ores, but no mention is made of limonite (brown hematite). The six faults of the Byram are also portrayed in the report, page 213. Some of its ore is a little stained with limonite. Wurtz describes the Dickenson bed as an immense cake or lens of magnetic ore, embedded in gneiss, and split on its edges with parting rocks which knife-edge far into the ore mass, which obeys all the contortions of the gneiss; no limonite is mentioned among its minerals; nor in the King mine, which is a compound bed with schist partings; nor in the Logan beds, which run 50 feet apart; nor in the Hibernia triple bed, with rock partings, drawn and described elaborately in the report page 222. Here also occur conglomerate layers of angular fragments of magnetic iron, decomposed feldspar, mica, etc. like those at the Allan mine above described, but cemented not with chalybite (carbonate of iron) but with calcite somewhat ferriferous; but no limonite is mentioned; the bed is sometimes double, 8 feet ore, 5 feet hornblende schist, 6 feet ore, dip 86° southeast, wrought 125 feet deep. It is not certain whether these three layers are the same as at the Lower Wood mine but this is probable. The Beach mines, also on the old Hibernia tract, nearly a mile southwest of the Lower Wood, cropping out 520 feet above the Hibernia brook and within 20 feet of the summit of the steep ridge, averages 3½ feet and dips 80° between hornblende schist, but shows no trace of limonite; neither do the Beachglen, Kitchell and Muir, and Sweed mines, all of which are mixtures of magnetic ore and hornblende in feldspar rocks with associated minerals but no trace of the hydrated peroxide of iron. The Beachglen is remarkable for its satisfactory evidences of aqueous origin, as Kitchell's figures show. The perverseness with which the old igneous theory compelled Mr. Rogers to overlook these facts and follow it backwards into what are now evident absurdities cannot be better illustrated than by what he says in his Report of 1836 (page 114) about the *date* of the origin of these beds, viz. that "in all probability the strata were at a pretty steep inclination previous to the appearance of the veins between the rock; for it is inconceivable how a forcible injection of fluid ore could enter a series of beds, lying

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in a nearly horizontal position without in any one case causing and occupying fissures *transverse* to the strata." Mr. Rogers could not help noticing this universal absence of branch veins; yet in spite of that observation, his theory blinded him to the fact that some of these veins lie at an angle of only 30°, while others are waved and bent in such a way as to make side branches inevitable—granting a run of hot metal—at any date of injection he might fix upon.

In the gneissic region of Southeastern Pennsylvania west of the Schuylkill and north of the Chester county valley are several important and curious beds of brown hematite, not instantly connected with limestone, but inclosed between Gneiss and New red sandstone. The gneiss country, undulated into parallel synclinals once filled in with tongues of new red sandstone, when it finally rose and lifted the new red to its present position in the air, seems to have been cracked afresh along its old synclinals, and as one side or the other of the crack went down a strip of new red carried down with it was preserved from the destruction of the rest. Long drainage through ferruginous rocks into the hollow of the surface along these downthrows then ensued resulting in the ore deposits. Such is Rogers's theory described in his Final Report, vol. i page 86, where he says "they have evidently been derived by percolation from their strata, by the long continued trickling of the surface waters in the lines of fracture." But the indefinite way in which he speaks of dykes and injections of granite, and the metamorphism of the New Red sandstone layers caught in the cracks, together with the doubt he expresses whether the Morgan Hoffman limestone "be a true igneous dyke or vein of carbonate of lime, or a closely compressed synclinal trough of sedimentary limestone metamorphosed by heat" leaves little influence to be exerted by his judgment in the premises. It is certainly possible, for all we know, that such a fissure should emit hot gases and even lava to act upon the rocks on either side. But where is the evidence of any such emission here; or that white feldspathic granite can be so emitted anywhere; and less credible is it still that white crystalline marble ever flowed molten from the earth. On the other hand a fissure kept always full of acidulated waters of a complex composition with very few and slow side accessions of mere sedimentary matter and that of course in form of feldspathic clay, must continue to be, until filled up, a laboratory of metamorphic

action; action directed as well upon its wall rocks as upon its slowly accreting sediments. No fire is needed, no igneous dykes, nor hot infernal vapors. The crack beneath it may be hermetically sealed. Time and the reagents present, evolving heat sufficient for the work, will do it well. It is from the causes of such a laboratory that the plumose mica in the geodes, the plumbago and mica in the red sandstone, and may we not add the granite facing of the gneiss must receive their exegesis.

The entire absence of limestone would make the genesis of these ores more difficult; but as Mr. Rogers says, several of the banks adjoin limestone; a strip of it has been uncovered in the Lewis bank; at Kimberton it occurs, sparry, with spangles of plumbago, within 200 feet.

East and west of Yellow Springs in the basin of Pickering creek, lie Lewis's bank, Fegeley's bank, the Latschaw mine, the Steitler bank, Jones's and other lesser deposits.[3] The first rests in a triangular cleft between steep northeast dipping Gneiss and southeast 45° pitching altered New Red sands and shales; white feldspathic granite close by the southern wall. The ore, a sandy brown variety, fills the crevice, "very little of it penetrating the adjoining rocks." Some of the red sandstone shows spangles of plumbago and crystals of specular ore. The red shales appear less altered. The quarry, 30 to 50 feet deep, lies along the centre of the valley in a line with another a mile northwest of Yellow Springs, and a third a little south of Kimberton, but the last appears in the absence of red sand to be a wash from gneiss. Lewis's ore goes to Phœnixville.

Fegeley's bank is one of two in the vale just back of Yellow Springs, lying in a similar trench between a southeast wall of Gneiss and a 40° southeast pitch of New Red, a hundred feet wide and as many deep. Half decomposed feldspathic granites penetrate the gneiss. The quarry of ore is 40 feet wide by 50 deep and 200 long; in the next bank the ore is 12 feet wide at the bottom. The two yield annually 4,400 tons of ore to Phœnixville.

The Latschaw and Steitler beds lie along another fault southwest of Yellow Springs. In both, the gneiss is nearly vertical with a *dyke* wall face of decomposing white feldspathic granite, against which (southeast) plunges the broken beds of sand and

[3] Described by Rogers, vol. i. p. 87.

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shale, the ore lying on the slanting crushed and squeezed New Red, here very crystalline, and full of scales of mica and plumbago *as if it were a gneiss.* The *Steitler* bed was wrought 50 years ago by Mr. Vanleer and has yielded annually for some years past from 3,000 to 5,000 tons of excellent ore, containing now and then a little black oxide of manganese and pyrites. Bombshells are very common in it; *inclosing* not rarely also *plumose white mica.* The neighboring *Jones's mine* is on another fault filled with fragments of gneiss, granite and highly altered red sandstone, cemented and mixed in throughout with ore. The southeast pitching rocks look here very much like gneiss.

The Montgomery and Chester county ore belt crossing the Schuylkill near Spring Mill is about a mile wide, occupying the southern margin of the limestone valley, flanked on the south by the Edge Hill and Barren Hill with its Sandstone (Potsdam or Primal) and extending its northern margin into the middle of the valley "beyond the narrow limit of the crystalline limestone or marble." The ore ranges in long narrow strips or tongues of ferruginous soil, covering the undulating outcrop of the limestone, the most productive belts being one north of Barren Hill and one north of the white and clouded marble. But good ore occurs in spots north of this general northern margin, as at Wood's bank, on limestone, under which lies sandstone. *Kirkner's* bank, east of the Schuylkill near Spring Mill, was opened about 1815. *Hitner's* banks near Marble Hall yielded in 1852 about 10,000 and in 1853 more than 12,000 tons of ore. The whole amount taken out annually from all the banks east of the Schuylkill along the limestone basin of Montgomery and Chester is estimated at about 60,000 tons.

West of the Schuylkill several banks lie in the narrow limestone valley south of Bethel. *Whitehall's* and *Fisher's* pits, a mile from the river, feed Merion furnace. The *Caldwell and Roberts's* old pit at the Baptist meeting-house, 76 feet deep lies on white marble. *Fisher's* large bank in Upper Merion yielded also excellent ore. At *Fisher's* new and *Widdart's* bank, supplying Phœnixville works, the proportion of dirt to ore was 3 to 1 in 1854. *Milliton's* bank supplied the Conshohocken furnace. *Otto's* new bank showed dirt and ore as 2 to 1. *Supplee and Hampton's*, *Hughes and Jones's* banks form a large group of small pits. South of Howelville small banks are owned by

Wilson, *Woodman* and others, one of which reverses the above proportion and giving 2 of ore to 1 of dirt to Phœnixville. *Jones's* and *C. Beaver's* large banks are half a mile from Centreville. *Buck and King's*, *Sam. Beaver's* are large banks; the latter is uncommonly near the northern margin of the valley. *Holland's* bank 17 miles northwest of Howelville was 45 feet deep and supplied Phœnixville in 1854.

West of Paoli *W. Buchanan's* yields 2 parts ore to 1 dirt and supplies the Conshohocken furnace. *G. W. Jacob*, *Maguire and Evans* have a number of banks further on towards the Ship tavern. *F. Neal* has three in a line.

West of Coatesville two or three small banks lie towards the southern side of the valley.[4]

The Lancaster county ore banks lie in isolated limestone basins surrounded by Potsdam (Primal) Sandstone No. I. Four such parallel basins cross Big Beaver creek, the longest not two miles long. A fifth crosses a branch of the Pequea, and a sixth wider than the rest crosses the Pequea and contains on its margin *Mylin's* pit, an open quarry at the junction of limestone and black slates opened recently in 1854 and yielding 5,000 tons in 1855 of moderately rich ore to the Lancaster furnace (Conestoga). Between the Pequea and Susquehanna are three more limestone basins long and narrow, the southern one (Eshalman's Run) containing *Coleman's* banks a mile from Shenk's ferry, the ore of which supplies Safe Harbor works. The second basin is a mile and half further north, runs from within a mile of the Pequea, across the Conestoga at Safe Harbor, and half a mile beyond, and contains another ore bank of the *Safe Harbor* works. A mile further north the third basin four miles long crosses the Conestoga above the works and contains a third bank with indications of others.

All these brown hematite ore deposits occur precisely at the junction of the Primal Slates and Magnesian Limestone (I and II) according to Rogers, and are in some cases true rock ores and not surface deposits. One section standing at an angle of 40° reads: Mica slate decomposed 14 feet; Sandy ore; Solid brown ore 6 feet; Mica slate sandy decomposed 10 feet; Talc slate blue decomposed 30 feet.[5] One of the mine shafts descends 135 feet and is worked by two levels.

[4] Rogers's Final Report 1858. Vol. i. pp. 216, 217.
[5] See section in Rogers's Final Report, vol. i. p. 218.

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The *Conewango* bank 50 or 60 feet deep and yielding 150 tons per week shows the ore as resulting from the decomposition and leaching of the ferruginous slates, one-third part of the mass consisting of the clay and sand of the slate. The ore yields about 40 per cent metallic iron at Conewango and York furnaces.[6]

In York county west of the Susquehanna a belt of brown hematite ores mixed with much oxide of manganese and therefore making a poor charcoal-iron keeps the southern edge of the Lower Silurian (Auroral) Limestone No. I, a little south of Hanover and of late years has been extensively mined.

Another belt follows (outside of) the northern edge of the limestone along the southern base of the Pigeon Hills, and was mined 45 years ago at Moul's, 5 miles northeast of Hanover, where rocky masses of it lie around upon a deposit a hundred feet deep, but the ore is too silicious to be valuable.[7]

Warwick Mine or Jones's mines in the southern corner of Berks county Pennsylvania, near the eastern disappearance of the Lancaster Limestone beneath the New Red as it approaches the Schuylkill, lies about three miles northeast of Morgantown, in an open quarry of five acres, with another of one acre south of it. Magnesian limestone (No. II), dipping 20° north 30° west over ore-bearing slates, forms the northern wall and is struck 50 feet from the surface in a shaft 180 feet deep, in the floor of which a boring 20 feet further down finds no bottom to the rock.

A trap dyke near the southern side penetrates the ore-bearing slates and is considered the cause of the magnetic and crystalline aspect of the ore, which is richest and purest next the trap in both mines. Some of the ore contains small amounts of sulphuret, carbonate and silicate of copper, which the American Mining Company of New York in 1850–4, undertook to extract with a magnetic separator but failed to make it profitable. The iron ore has been mined with more or less regularity ever since the Revolutionary war and Mr. Rogers states the product in 1853 to have been about 7,000 tons, and the annual product for the four years of the copper enterprise including 1853 not less than 10,000 tons.[8]

[6] Rogers's F. R. p. 219. [7] P. 223.

[8] Rogers's Final Report vol. i. p. 182. Annual Report of 1840.

The position of this mine may be profitably compared with that of the Amenia and similar mines in eastern New York with limestone on one side and gneiss upon the other.

Chestnut-hill brown hematite ore bank, of which a very satfactory picture is given on page 183 of Rogers's Final Report vol. i. is situated 3½ miles northeast of Columbia Lancaster county Pennsylvania, in a high valley of apparently synclinal structure of gentle dips, quite flat in the centre, where the ore is worked by open benches to a depth of about 100 feet, the ore prevailing throughout from top to bottom. The great mine occupies about a dozen acres. Grubb's mine is half a mile distant. The floor of the mine is hard white Potsdam sandstone or the grey slaty layers over it. The walls show horizontal wavy layers of blue, yellow and white laminated unctuous clays from 40 to 60 feet deep containing ore, and under these an irregular layer of hard concretionary cellular fibrous brown hematite ore from 10 to 30 feet thick down to the sandstone floor, which is still the water-bearing rock of the neighborhood. Other consolidated layers of ore may be detected overlying occasional local seams of tighter clay.

Crystalline magnetic ore is seen at one point only in this mine, in a band three or four inches thick containing small octahedral crystals. Mr. Rogers has no hesitation in ascribing its presence here to *heat* and in accounting for the fact that in the Warwick and Cornwall mines it is so much more abundant by supposing a more energetic heat. But he offers no conjecture on the strange way so general an agent as heat could find to enter a great mine at but one point and confine its magnetizing and crystallizing work within the limits of a layer not half a foot in breadth. No doubt the chemists will explain the presence of these crystals in a better way.

The celebrated **Warwick** and **Cornwall** mines in Berks and Lebanon counties Pennsylvania are described by Rogers as openings in the ferruginous uppermost layers of No. I, his upper Primal Slate, just underneath the lowest layers of Trenton Limestone, No. II, his Auroral Limestone, and they belong therefore properly neither to the primary system nor to the brown hematite system of our ores. The equally celebrated **Chestnut-hill** bank in Lancaster county exposes the lower strata of the same (Upper Primal) slate down to the floor of Potsdam (Middle Pri-

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mal) Sandstone No. I. Evidently the ore was an original dissemination through the sandy mud layers which hardened into slate. The surface waters, which were then more copious and perhaps much warmer than at present and was charged, it may be supposed, with carbonic acids and other volcanic exhalations of that stormy atmosphere, washed through the mass carrying down the iron as a peroxide to the face of the sandstone or against the upper side of the occasional layers of lighter clay which hindered their descent. If the sulphur was in excess at first, that is, if the iron was in the form of sulphuret when disseminated (not a probable supposition), then we must suppose it leached away in the form of free sulphuric acid. But, as the very reason why this great bed of ore lies here is that the slates were here horizontal and the iron therefore could not be carried off, we must conclude that all the original sulphur is here also, and that presupposes the original dissemination of the iron in the form of a carbonate or of a hematite. If of a carbonate, then we have at this early day an antitype of events repeated in the coal measures, where disseminated carbonate of iron has been leached through its containing sandy shales down upon the face of Limestone layers like the Buhrstone or great lower fossiliferous Limestone of Northwest Pennsylvania. The same filtrating process is illustrated in the fossil ores of the Clinton (Rogers's Surgent) No. V Formation, where peroxide of iron has descended to envelop whole layers of shells and grains of sand, but under very different circumstances.

In the case of the Fossil ore of V it was earnestly debated fifteen years ago among the geologists of the Pennsylvania survey whether the facts then known respecting it would warrant the assumption that it was only rich where flat and always lean where it stood steeply pitching. The question involved, as every one can see, the origin of the iron,—not in the Formation, but in its particular bed; for if it could be determined to be true that the thickness and richness of the ore deposit was in proportion to the gentleness of dip, and was at a maximum when the bed was horizontal at the bottom of a trough, it would in reason follow that the deposition of the ore in its present bedded form was a separate and subsequent affair to the original formation of the rocks,—subsequent of course to the upheaval and entroughment

of the whole formation,—consequent in fact upon its entroughed or horizontal posture. In other words the leaching waters must be stopped by some sort of diaphragm or filtering screen, and this could not so well happen where the rocks were steeply inclined and the waters found their way between the layers, as when the rocks lay flat and the waters seeped directly through their sand against some lower face of clay. At that time so little had been done in mining the fossil ore of V that the question could not be answered; in fact it cannot yet be answered with an absolute conviction; but yet enough is known to make it probable that the fossil ore will be always found more abundant in its beds where these lie pretty flat as at Norwich, Clinton, Bloomsbury, Frankstown, Cumberland and Cumberland Gap, than where they stand more erect as at Chulasky, Lockhaven, and along the outcrops of the steeper anticlinals of the Kittatinny and the mountains back of it.

But another point of evidence in the case of the Fossil ore of V and the Buhrstone ore of the coal measures must be observed before we apply the example to elucidate the case of the older ores. The abundance of fossil life encased in iron was at first a mystery. The waters in which these creatures lived must while they lived have been approximately pure. They lived upon clay and were entombed in a sandy mud. The iron must have come in with the sandy shales above, in which few fossils are found, and subsequently percolated to the fossil bed below, enveloping the shells and grains of sand.

That the original introduction of iron where we see it now in a state of high oxidation was no local act is well known. The fossil ore of V extends from Middle New York to Alabama and Wisconsin. The buhrstone beds of XII are coextensive with great areas of the coal. What shall we say then to the appearance of brown hematite deposits along the outcrop of the Trenton Limestone and Potsdam Sandstone (Formations I and II) from Canada East to Alabama, and in the interior valleys wherever these formations lift themselves to-day? But the obvious conclusion cannot be confined to the case of beds that occur within the limestone limits; it must avail in discussing the genesis of the Cornwall, Chestnut-hill and Warwick beds, in the slates below the limestone. The fact that the same phenomena appear at these three points distant from each other scores of

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miles, and at many others[9] proves that they are not local deposits in the strict sense of the term, in the sense in which lava outbursts for example are, or igneous veins of any other kind, if any other kind there be. The waters of that opening age of life may or may not have been more troubled than our own, and oceans may have been larger or smaller then than now; but certainly coasts more indented, islands more numerous, oscillations of the crust more frequent and currents engaged with coast lines of more original and various minerals than now, must have made mineral deposits less homogeneous and evenly spread out than those of later days. Absolute synchronism was not half so possible as it became in after times, and it is not to be wondered at that the inflows of iron stuff should have occurred at one point a few yards lower (that is earlier) in the Primal Slates than at another point distant fifty miles.

Now when we add to this the element of *posture*, we recognize at once how little chance, in an old, contorted, complicated region like southeastern Pennsylvania, the Primal Iron Slates would have to maintain a flat position favorable to the perfect hematization and collection of the ore in layers and masses at the bottom; at how few points therefore the actually universal presence of the iron would afterwards succeed in manifesting itself in such magnificent displays of mineral wealth as these.

It ought not to be accounted out of place here, for the whole course of the argument is backward in the line of time, to end it with the probability that the so-called *primary* veins, penetrating still older systems of rocks than these, were once, like the above described, deposits of brown hematite, converted to their present state by a metamorphic agency not yet to be well explained. Their frequent sedimentary aspect, their continuity and discontinuity at once, their parallel imbedment between sedimentary rocks, the presence of zinc as in the brown hematite beds, and of phosphorus and phosphate of lime, all point to the confessed *analogy* between them and the brown hematites as a probable *identity*. The absence of sulphur leaving many of the primary iron ores cold-short is no conclusive objection to

[9] Large deposits of brown hematite are not infrequent in the soil of the Primal Newer Slates. Throughout the Appalachian chain much valuable iron ore is discovered in connection with the same formation. (Rogers, vol. i. p. 202.)

considering them originally deposits of brown hematite, since some of these yield also cold-short ores; and an excess of phosphorus or silica would make them so as well as the absence of sulphur; while in many primary ores sulphur is an abundant element. That Iron ever flowed from the earth like lava is becoming doubtful to many well trained minds; and where a sedimentary origin can be so reasonably argued and inferred, and seeing that the rocks in which the primary ores are found have ceased for some years to receive the name of *primary*, and are now well proven to be sedimentary themselves down to the lowest layer visible upon the oldest ground examined yet, it seems unwise to base our practical geology in iron upon an igneous theory.

It is now known that the Mediterranean sea water holds so large a proportion of copper in solution as not only to color itself thereby its deep peculiar blue, but to deposit the metal upon and within all objects floating in it for a length of time, and of course the mud collecting in its bed. This when hereafter dried and hardened, if the world last long enough for such a change, will resemble somewhat the cupreous shales of Formation VIII in the Devonian system of the United States.

It is also known that the Atlantic Ocean water holds a percentage of silver in solution, and electrotypes all copper-sheathed vessels with it. Of course its limestone deposits are argentiferous like those of ancient days—days when gold also was thus held suspended and precipitated with gelatinous quartz derived from boiled and acidulated sand, in beds of sulphur-iron slate.

Much ore follows the northern base of the Easton or Durham hills at the lower or southern limit of the Lower Silurian Limestone No. II, as, near the Philadelphia road two and a half miles south of Allentown and between Emaus and Millerstown, in abundance. But the ores of eastern middle Pennsylvania are found at some distance north of the base of the mountain.

The principal line of beds begins five miles north of Bethlehem in soil-deposits a hundred feet deep resting on limestone. The ore is small and must be washed and screened. This belt crosses the Lehigh three miles above Allentown, where it yields pipe ore and much red oxide of iron in clay between the limestone outcrops, all needing washing. West of the Lehigh it curves northward and then westward keeping one wall of limestone and being at least 70 feet in depth. The deposits follow the tongue of Limestone II which runs westward into and under the Lower Silurian Slates III. North of Jordan creek on to Sieger's tavern ore abounds near the margin of the slate.

The noted **Balliot mine,** one of the best in eastern Pennsylva-

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nia and long worked, lies near the northern limit of the limestone where it goes under the slate, and yields honeycomb ore near the surface and compact ore below. In one of its northwestern workings a deposit of black oxide of manganese was struck, said to be four feet thick. Large deposits of sulphurous clays are characteristic of parts of this and other brown hematite formations. The line of ore-beds above mentioned continues southwest to *Shoemaker's* old mine (deserted) two miles north east of Trexlertown, where also and in the interval country between it and Millerstown and Breinigsville is much ore found. Manganese appears near the Trexlertown big spring, and a mile further west occurs a noted *copperas iron mine*, three borings in which, given by Mr. Rogers, are of interest in discussing these deposits.

	Feet.		Feet.		Feet.
	15	Clay, gravel	30	Clay	14
	1	Iron ore	$4\frac{1}{2}$	Iron ore and Clay	8
	15	Clay	$7\frac{1}{2}$		
				Iron ore	9
Slate	5	Black clay	2	Clay	3
In clay	6	Sulp. iron	12	Copperas earth	6*
Pipe ore & clay	9	Iron ore	5	Brown clay & ore	8
				Rock iron ore	2
				Clay	8

The Copperas earth marked 6* has its middle two feet mixed with black clay and its lowest two feet with white clay. The black oxide of manganese is found in the upper part of the iron ore in the west side of the mine. The silicious slate is somewhat gypseous from the reaction of sulphate of iron on carbonate of lime. Mr. Rogers, or the Pennsylvanian geologist who furnished this chapter of the Final Report, ascribes the abundant sulphuret of iron here to a shallow bed of black slate No. III, which appears to have once rested on the limestone and subsequently undergone disintegration. Trexler's furnace south of Metztown gets its ore from numerous banks, as far as Kutztown and Moselem, mixing it with *magnetic* from three miles south.

The **Moselem bank** is one of the oldest and finest in the country, lying five miles west-southwest of Kutztown and is, like Balliot's bank, near the northern border of the Limestone II where it passes under the Slate III and within 1,000 feet of the foot of

the slate hills. The ore is commonly reached in from 20 to 40 feet from the surface, and lies in nests and irregular layers from one to eight feet thick, some of it bluish and manganesian. A gentle southwise rise carries the limestone under it up to the top of the ridge next south of the mines covered with loose masses of dark-colored chert some of them weighing several hundred weight. White clay is found in the ore bank.

Hampton furnace (E 48) uses beds in its neighborhood 12 miles southwest of Allentown; Mary Ann furnace (E 49) 18 miles northeast of Reading has its own beds within one and two miles; Oley furnace (E 50) uses Deishler's ore eight miles north-east of it; Sally Ann furnace (E 51) uses Trexlertown and Mose-lem ores; Mount Laurel furnace (E 52) six miles north-northeast of Reading uses Moselem, Dumm, and Hefner ores in Richmond township 14, 11 and 16 miles northeast of Reading and 8, 6 and 10 miles from the furnace, the two last mentioned lying along the South mountain. Maiden creek furnace (E 53) uses Moselem (7 miles) Coxtown (10 miles) Trexlertown (13 miles east) ores.

West of the Schuylkill the brown hematite ore-beds have been opened in many places, but are commonly of small extent. In this part of the valley the Cornwall ore-bed described in the last chapter almost monopolizes attention, and all the furnaces run upon it more or less. Hampton, Joanna, Hopewell and Keystone furnaces use the Warwick and Chester county mines. The Union Deposit (A 82) eleven miles east of Harrisburg uses Cornwall ore, but has two small brown hematite deposits (Herthey and Union Deposit Banks) three miles north of it.

The Primal newer slate sustains extensive surface-deposits, of a somewhat distinctive variety, of brown hematitic ores, a few descriptive and theoretical observations upon which may not be out of place here. These relate not only to the ore of this formation as it is seen in Pennsylvania, but to the whole enormous outcrop of the stratum wherever it is largely developed from Eastern Tennessee to the Green mountains of Vermont.*

This iron ore is lodged in extensive accumulations of yellow ferruginous loam and clay, occupying hollows or basins in the surface of the Primal newer slate, at the northwest base, or low on the northwest slopes, of the ridges and spurs of the South mountains of Pennsylvania, or of their prolongation the Blue Ridge in Virginia and Tennessee, and the Green mountains in Vermont. Diluvial waters have apparently caused these deposits of loam, into the lower parts of which the particles

* This, and what follows, is from Rogers's Final Report, Vol. II.

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of the oxide of iron have been conveyed by the dissolving and transporting action of percolating waters, and there collected into irregular nodular masses of very various structure. Some of these are stalactitic, but the ore of the Primal slate is more frequently in roundish cellular lumps, and even sometimes in hollow bomb-shaped geodes. The latter often consist of crystallized fibrous hematite, but the earthy brown hydrated peroxide is by far the most commonly met with. The masses are distributed in the loam without definite stratification, or any apparent order, being in greatest abundance towards the bottom of the deposit.

In some of the present class of mines, though not in all. there occur, mingled with the iron ore, small masses of peroxide of manganese, and these are occasionally stalactitic in their form. The oxide of manganese is, moreover, chemically combined with the oxide of iron in much of the iron ore, and when in any considerable abundance, is a serious hindrance to the fusion of the ore in the blast-furnace. For this reason it is that these ores have usually been less in favor with our iron-smelters than the purer varieties which overlie the adjacent tracts of the Matinal limestone. Respecting the ultimate source of the oxides of iron and manganese, it is to be sought in the ferruginous slates upon which the deposits repose. The loamy soil imbedding the ore appears to have been derived from the disintegration of the slate previously collected in a fragmentary or even pulverized condition in the depressions of the surface. Under the action of the percolating rain and springs, these materials would be converted into a mere loam, and the oxide of iron set free. Much of the iron has been originally in the condition of the sulphuret of iron, diffused in minute crystals through certain layers of the slate. The facility with which this mineral undergoes decomposition, and gives rise to hydrated peroxide of iron upon the access of atmospheric air and the rain water, is a fact familiar to chemists. This view of the origin of a part at least of the ore, accords with what is known concerning those slaty rocks which contain much sulphuret of iron.

Such strata become changed in their exposed or outcrop portions with the brown peroxide, and where circumstances have favored a deep and general decomposition, we find nests and seams of the peroxide associated with masses of the rock in all the intervening stages of chemical change. Among those older metamorphic micaceous and talcose schists which are sufficiently pyritous, these conditions are as frequent as among the slates, shales, and limestones of the Appalachian Palæozoic formations. The separation of the peroxide of iron from the other materials of the disintegrated slate, is sometimes so complete as to leave a white earthy residuum of finely-subdivided particles, having the character of a pure silicious clay. This occupies the interstices between the nodules of ore, and is common in the interior of the hollow masses. So entire a separation of the oxide of iron from the earthy substances as this clay manifests, must be attributed to some further action than the mere transporting power of the percolating waters. It seems to imply the operation of a *segregating force* among the particles identical in chemical nature, in obedience to which the atoms of oxide of iron have detached themselves from the other matter, and concentrated themselves around particular centres, as in other cases of nodular concretion.

The peroxide of iron is very slightly, if at all, soluble in pure water, but is dissolved to a certain extent by water impregnated with *carbonic acid.* The superficial waters containing a portion of this acid, derived from the atmosphere, through which they have all fallen in the form of rain and snow, are capable of slowly conveying the peroxide in a state of solution from the surface to the deeper parts of

the mass, where, by the gradual escape of the carbonic acid, the peroxide has become deposited. In the decomposition of the common sulphuret of iron, such as is found in pyritous slates, the sulphate of iron formed is *very soluble;* and this, pervading the surrounding mass, has gradually given up its oxide of iron by a decomposition promoted by the presence of earthy and especially of calcareous matter.

Respecting the origin of the Auroral limestone ores, there appears to be no necessity for referring to any other agencies than those alluded to in treating of the history of the ores of the Primal series. Waters impregnated with salts of iron readily deposit the peroxide when in contact with carbonate of lime, and we might therefore look for deposits of the ore in situations favorable to the accumulation of the debris of ferruginous slates, and to the infiltration of waters charged with sulphate of iron derived from the decomposition of the sulphuret contained in such slates. Many of the layers of limestone, especially those of a slaty structure, contain much sulphuret of iron, and the great mass of the Matinal limestone formation includes a large amount of but slightly calcareous slates, more or less pyritous in their composition.

Among the circumstances which usually indicate an abundance of the limestone ore beneath the soil, it should be mentioned that one of the most essential is a considerable thickness in the deposit of ferruginous loam, clay, or other earthy matter, resting on the strata. This will, of course, be marked by a corresponding evenness of the surface ; for where the beds of limestone are naked of soil in many places, the covering of earth, which must contain the ore, can nowhere be deep. Another very necessary condition is, that the earth overlying the rocks should have a large amount of the oxide of iron diffused in it. This will show itself by a characteristic bright yellow or clear brown color It must be observed, however, that the existence of a large quantity of oxide of iron in the deeper part of the soil will very frequently not be perceptible in the color of the surface of the ground—the ore being confined to the lower portions of the mass—so that much good ore-ground is often neglected from want of perseverance in digging.

The iron ores of the Matinal slates are obviously traceable to sources similar to those of the ores of the Primal slates and Auroral limestone. In the Matinal slate ores, the proportion of oxide of manganese is often very great, and not unfrequently the ore passes in neighboring beds into nearly a pure oxide of manganese. Indeed, it is chiefly in the upper part of the Matinal slates, and in the Primal slates, that this latter mineral is met with in deposits of sufficient extent to be valuable. The olive-colored layers of argillaceous and sandy slate, forming a chief part of the Matinal newer slate, owe their color in great part to the large amount of protoxide of manganese which they contain. In the disintegration of the rock this is dissolved, and being converted into peroxide by exposure to the atmosphere, is deposited in irregular layers or concretions in situations favorable to its accumulation. [Mr. Rogers continues, referring to his own book,]

Having in Vol. I. page 263, expressed a hope of being able, before the completion of this work, to present some more recently collected details of the Surface Iron Ores of the Kittatinny Valley, I here introduce the results of observations since made respecting the chief mines between the Delaware and Schuylkill rivers.

Of the District between the Delaware and Lehigh Rivers.—*Goetz Mine.*—This is an old and extensive pit, and the only one from which ore is regularly obtained in the district northeast of the Lehigh river. It is situated within the valley of limestone, four miles north of Bethlehem. The excavation, which has eached a depth of nearly 60 feet, extends over two-thirds of an acre. The ore is

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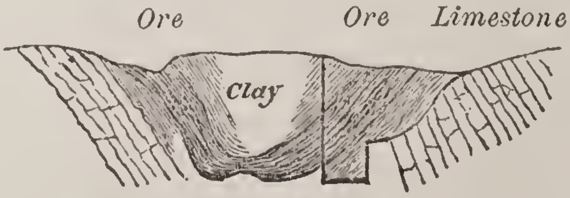
chiefly a bright red hematite or hydrated sesquioxide of iron, the origin of which is clearly betrayed by numerous large masses of silicious rock found in the mine. These masses closely resemble the ore externally, and are, indeed, partially converted for some distance beneath the surface. In one part of the mine the rock was found somewhat regularly bedded over a mass of ore and clay, but it has been cut away to reach the materials beneath. In its texture it is a rather coarse sandstone of limestone-blue color, and evidently contains lime. It may be termed a very sandy limestone or calcareous sandstone. The bed of ore at present mined underlies a thick mass of light-blue and ferruginous-brown clays. Its dip, which is flat near the surface, steepens to 45°, and again turns nearly horizontal at the floor of the mine. It crops out towards the northwest. In thickness the bed varies from a few feet up to 15 feet. In the southeast parts of the mine no ore is at present excavated, and rubbish has obscured the bedding, if it has any. The clays contain disseminated masses, which may be separated from impurities by washing. The nearest rock exposures are of limestone, dipping southeast at a high angle. The yield of the mine does not exceed 4,000 tons per annum.

Of the District between the Lehigh and Schuylkill Rivers.—*Beisel's Ore-Mine* is situated on the Catasaqua and Foglesville Railroad, five miles from Catasaqua. It is an open pit of red hematitic ore, lying closely adjacent to a ridge of limestone which dips nearly vertically southeast The ore is irregularly deposited, not in any stratified bed, but in nests or bunches, and cannot be traced to any considerable distance from the mine. The pit, which is 50 feet deep, is wrought for the Lehigh Valley furnace, the ore being raised by an inclined plane and horse-power. A fourth of a mile southeast of the mine rises a conspicuous ridge of calcareous slate, and at the foot of this is the

Trexell Ore-Mine, wrought by the Crane Iron Company. The ore is raised by steam-power, from a shaft sunk 60 to 70 feet. It is very irregularly disseminated through clay and earth, but little lump ore being found. All the material raised from the pit requires washing, and the ore is not very abundant. The yield of the mine is 2,000 tons per annum. In neither this nor the preceding mine has the rock-floor been reached.

Ritter's Bank is at the foot of the limestone ridge, in the prolongation of Beisel's ore-deposit, and but a few hundred yards distant. It is but recently opened, and the mine is small In character and mode of deposit it in all respects resembles Beisel's. The ore is smelted at the Lehigh Valley furnace.

The Guth Mine has been wrought for many years, and is now leased to the Crane Iron Company. It is situated on the west side of the prolongation of the limestone ridge which passes Beisel's and Ritter's mines. This is apparently a monoclinal ridge of limestone, dipping steeply southeast. The ore at the Guth mine occupies a narrow trough which has been carved out of the limestone, as shown in the annexed cut. At its east outcrop the ore was 20 to 30 feet thick, and inclined 75° west. It rests upon clay and sandy debris, and is overlaid by black clay, containing a large quantity of sulphuret of iron. This is capped by a tough white clay, which, when wet, assumes a semi-fluid condition, and soon covers the freshly-cut face of the mine. The insecure character of such a roof has prevented the mining of the ore where the increasing thick-



Guth Mine.

ness of the covering makes it too expensive to remove it from the ore. Within 80 feet of the surface the ore-bed basins, but is somewhat thinner, and rises to the surface upon an east dip, within 200 feet of its east outcrop. On this side the ore has not been extensively wrought. The basin rises out within 100 feet northeast from the pit, and the ore cannot be traced farther in that direction. In the main pit the ore is a velvety brown and black hematite, changing to red near the outcrop at the northeast end of the mine. Southwest of this pit there are two others, within a few hundred feet. In the first of these a shaft, sunk to the depth of 80 feet, passed perpendicularly through 40 to 45 feet of dark-brown and black crumbly ore, dipping steeply northwest. Between this mass and that in the preceding pit the connection has not been traced, the thickness of the ore deposit having greatly dwindled in the interval. The third opening does not merit attention; it was abandoned because of scarcity of ore. The yield of these mines is about 5,000 tons per annum.

Kern & Albright's and *Hoffman's Mines*, closely adjacent to one another, are situated half a mile southeast of Siegerville, and a fourth of a mile from Jordan creek. The bedding of the ore in the former pit dips northwest 20°, and rises upon the opposite dip in Hoffman's Mine. The two outcrops are about 500 feet asunder. In neither of these openings has the bottom of the ore been reached, though from 20 to 25 feet in thickness have been wrought. The ore is a brown oxide, quite regularly stratified; but the floor of the mines being covered by water, it could not be critically examined. It is capped by black clay, richly impregnated with sulphuret of iron, which is overlaid by white and variegated clays and earth. Between the two mines the ore is wrought by drifts and gangways in various directions. As is usual at the larger mines, the ore from both of these pits is raised by steam-power up an inclined plane. Hoffman's mine, wrought for the Allentown furnaces, was not in operation at the date of our visit. Kern & Albright's, leased by the Crane Iron Company, yields from 9,000 to 10,000 tons per annum. From these mines the surface slopes gently southeast towards the Jordan, and is deficient in rock exposures; on the northwest, however, we find the limestone dipping southeast beneath the ore of the Hoffman pit.

Kern and Albright's and Hoffman's Mines, near Siegerville.

At Siegerville an ore-pit was opened some ten years ago by Mr. Sieger, and has been wrought by several iron companies, but is now abandoned. There is evidently a large body of valuable ore at this point, but the dilapidated condition of the mine prevented an inspection of its bedding or thickness. The dip is said to be northwest, and 68 feet depth of mining did not reach any rock-floor. The excavation extends over one-third of an acre.

Xander's old bank, the property of the Crane Iron Company, is one-third of a mile northeast of Siegerville. This mine has not been wrought for six years, and is now in ruins. The ore, which is of the usual dark-brown hematitic variety, formed a bed dipping northwest, of a thickness varying from 12 to 20 feet. It was overlaid and underlaid by silicious pebbles. The position of this mine is near the boundary of the Auroral limestone, and the overlying Matinal slates, although these rocks are not found *in situ* in the vicinity of the mine.

Jos. Balliot's Mine and *Mickle's Mine*, separated from each other by the roadway, are situated three miles northeast of Siegerville, and within one-fourth of a

mile of a range of hills formed of the Matinal slates. In the former and larger pit the ore is almost exclusively of the brown variety; in the latter it is of a bright-red color, and more crumbly character. The bottom of the deposit has not been reached. The bedding of the ore is horizontal. Beneath the upper stratum of brown ore in Balliot's pit reposes a band of black clay containing occasional masses of brown ore. These mines are very wet.

Stephen Balliot's and *Jeter's Mine* (formerly Shierey's) at Ironton, one-fourth of a mile northwest of Jos. Balliot's, is a large excavation. From it the surface slopes gently south towards Copley creek; within a quarter of a mile northwest the boundary of the Matinal slate ranges along the conspicuous ridge above mentioned. This, as well as the other mines in the neighborhood, seems therefore to lie among the alternating slate and limestone strata of the two formations. The gently rounded surface of the hills, and the entire absence of rock exposures, make it impossible to say under what precise conditions the ore has been deposited, with relation to the character and inclination of the subjacent strata. The nearest exhibition of rock displays limestone dipping northwest, towards the slate range, at a moderately high angle. The ore of this mine is of the usual brown hematitic variety, and is frequently quarried out in large masses; over the more solid body of the brown ore there is usually about 10 feet thickness of a more cellular honeycomb ore. The extreme depth of the pit is 50 feet, and ore has been mined throughout the distance. The floor of the deposit was not reached by a well sunk 16 feet from the deepest part of the mine. In a neighboring smaller pit, belonging to Mr. Balliot, both brown and red ore are obtained, though from different parts of the mine. The brown ore has a bedding which inclines 45° southeast. The ore deposit at these mines is evidently a most extensive and valuable ore; but, as at present wrought, the annual yield does not exceed 4,000 tons. Between it and Ritter's pit, a fourth of a mile farther northeast along the same range, ore may be traced on the surface, and has been proved at several points. The continuity of the deposit between the two may perhaps be interfered with by a gentle rise prolonged from a knoll of limestone.

Ritter's Mine, leased by the Crane Iron Company, displays a fine body of brown hematite ore, varying from 30 to 40 feet in thickness, except at the outcrop, where the deposit is 12 feet thick. The dip is northwest, undulating at an average angle of 30°. The floor is of clay. Over the good ore the black clay is found, capped as usual by white clay and surface materials. The depth of the pit is 45 feet, and its yield 6,000 tons per annum. The limestone forming the lower slope of the slate hill dips southeast towards the mine.

The slate ridge which forms the boundary of the valley of the Auroral limestone on the northwest ranges southwest from the vicinity we have last described, near the village of Foglesville in Upper Macungy township of Lehigh county. Two miles southwest of Foglesville it deflects south, and then northeast for a mile as a spur, which courses southwest as the general boundary of the limestone. The little cove of limestone thus inclosed is the seat of several rich deposits of hematite ore, which are extensively mined.

Sclough's Mine is situated one and a quarter miles south of Foglesville, at the northeast end of the slate ridge to which we have just adverted. East and south of it the soil is all of limestone origin. The mine, though quite small, being recently opened, is interesting, as showing the hematite ore in several stages of development. At the pit the ore is a compact rocky brown and black hematite,

graduating into a more rotten brown ore and ferruginous clay. In the trial shafts sunk west of the mine, the ore became more and more slaty, receding from the main body, and assumed the character of a rotten ferruginous slate quite valueless as an ore. The bedding of the ore has a gentle southeast inclination. The limited explorations that have been made do not warrant any judgment as to the extent or depth of the deposit. In the well sunk for water near the pit to a depth of 64 feet, black carbonaceous slaty limestone was encountered 36 feet beneath the surface, and continued to the bottom.

Haine's Pit is a small excavation three-fourths of a mile southwest of Foglesville. It is now abandoned and in ruins. The ore is quite slaty in character, and apparently not abundant.

Miller's Mine is in the limestone cove southwest of Foglesville. Like all the others, it is an open pit, from which the ore is raised by a slope plane and steam-engine. Its depth is 35 or 40 feet, extending over half an acre. There is a covering of from 5 to 25 feet of slaty debris over the irregularly-stratified ore. The bedding of the latter dips at a moderate angle southeast, but in that direction the ore rises to the surface again 100 yards distant, and was formerly wrought at the outcrop. As the bed sinks from the surface along the dip, the ore becomes more and more solid; but at places in the mine it is replaced by bodies of clay. A well sunk from the bottom of the pit to a depth of 18 feet, proved ore throughout that distance, though becoming lean at the bottom. The yield of this mine is about 2,000 tons per annum. Leased by the Crane Iron Company.

Laurish's Mine, a few hundred yards west of Miller's, is a small excavation not now wrought. Many fragments of the ore look not unlike a merely ferruginous slate externally, but when broken exhibit a close-grained brown hematite. The mine has been wrought for the Allentown furnaces.

Lichtenwalder's is an old pit lying close to the ridge of slate which bounds the cove on the west, and one-fourth of a mile from the last mine. The extreme depth of the pit is 55 feet. In some places the ore, all of which is brown hematite, cavernous and velvety, is 40 feet beneath the surface, and at others it approaches and even outcrops upon it. There is no apparent or regular dip in the bedding of the ore, but the mass has a general inclination southeast. In parts of the mine white clay overlies the ore; in other parts surface materials are intermixed with it, in which cases washing is resorted to. The solid and softer ores are irregularly intermingled. From the deepest part of the mine, a well reached the clay bottom of the deposit at a depth of 14 feet. Yield 3,000 tons per annum. Ore delivered to the Crane Iron Company.

It is worthy of remark that in all the hematite ore pits hitherto described, frequent cavernous, amorphous masses of flint rock are found disseminated, chiefly among the clays and softer ores. We also notice in the undecomposed calcareous slates which occupy the ridges bordering the ore districts, numerous crystals of sulphuret of iron.

Breinig's Mine is an old pit, now but little worked, on the southwest prolongation of the slate range from Sclough's Mine, two miles northwest of Breinigsville. There is no appearance of any stratification in the ore, but it is disseminated through ferruginous earth, which is washed, and the ore picked out. The mine is in confusion.

Two miles northeast of Trexlerstown are the mines of *Gachenbach* and others, formerly known as *Shoemaker's Mine*. There are several pits upon the same great body of ore, which dips rapidly (45°) towards the southeast. The ore bed has a

thickness of 42 feet at the pit, including the interstratified clays. It is exclusively red hematite, becoming harder and more rock-like as it gains cover. At the main pit, from which ore is now raised, it has a covering of 25 feet of surface-earth and clay. This pit is 50 feet deep, but ore has been proved 24 feet below the level of the m ne resting upon a cavernous limestone. All the limestone near the mine dips southeast. There is no appearance of slate. Yield 2,500 tons per annum.

Wickert's Mine is situated one mile east-southeast of Texas, in Lower Macungy township, and about two miles from the range of the South mountains. The soil is underlaid by limestone, and the ore is obtained from shallow pits, and by stripping the surface. It is so mixed with clay and earth as to require washing to separate it from impurities. The ore, which is a rich brown and black hematite, is invariably found in small angular or formless fragments, and sometimes as hollow geodes. Occasional fragments of ferruginous slate and slaty ore betray its slaty origin, and the presumption is that the slate from which it was derived was interstratified with limestone. The locality is not now wrought, but it has yielded 2,000 tons of ore. A few hundred feet distant is a much deeper and more extensive deposit at *Gideon Andreas' Mine.* The pits have reached a depth of 20 feet, extending over one-third of an acre. Occasional masses of rich brown hematite are found, but the chief part of the ore is intermixed with ferruginous clays, which are washed. There is no appreciable or regular bedding of the ore. The precise yield of the mine we did not ascertain, but it probably amounts to 3,000 tons a year. In the same immediate neighborhood are *Yobst's*, *Christian Andreas'* and *Weygandt's* open-pit mines. In all of these the ore is washed from ferruginous earth, with which it is so intimately associated that the uninitiated eye would fail to detect its presence. The yield from the washing is about one-fourth or one-fifth part ore.

Schmoyer's and *Rheinhart's Mines* are three-fourths of a mile northeast of those last mentioned. In the first of these there is no regularity in the bedding of the ore, and all the materials derived from the mine undergo washing. In Rheinhart's pit the ore deposit is embraced in an undulating belt of 18 feet. In the wells sunk for water to wash these ores, limestone is invariably encountered at a considerable depth, but its dip we were unable to ascertain. The Schmoyer mine yields about 1,000 tons per annum, delivered to the Crane iron furnaces. The product of Rheinhart's pit, about equal in amount, is smelted at the Allentown furnaces. Near by is an old mine, now but little wrought, known as *Mark's* or *Whiteley's.* The somewhat undulating deposit is 30 feet thick and uniformly bedded.

Sigler's Mine, two miles north-northwest of Mertztown, is situated near the base of a slate ridge which projects into the limestone valley from the great slate range beyond. The mine has been wrought many years. The stratification of the ore is very confused and irregular, though there are some evidences of a general southeast dip. In parts of the mine the masses of ore are found imbedded in clays, and are frequently so intersected by veins of quartz as to be rejected. The present yield does not exceed 1,000 tons per annum. There are several recently-opened small pits in the same neighborhood, but they furnish nothing worthy of especial remark. In some of them the ore is brown hematite, in others red.

In the vicinity of Kline's store, and elsewhere along a narrow belt ranging with the valley, ore has been proved by surface shafts and small pits at numerous points. All of the ore derived from these openings is of the silicious brown variety, in various degrees of purity. Many specimens appear rather as masses of rotten, ferruginous, and perhaps calcareous sandstone. These masses are generally large and

cavernous, containing a yellow calcareous clay within. The excavations are too limited and superficial to afford us any insight into the structural features of the limestone strata beneath these deposits.

Trexler's Mine is one mile southeast of Breinigsville. It is but recently opened, and the excavation has not proceeded far, but fine large masses of brown and red hematite are found plenteously scattered through the rich ferruginous earth, which is washed to obtain the smaller fragments. The disintegration of the underlying rock has been deep, as is proved by a well 80 feet in depth, wherein no solid rock was encountered. The mine is upon the top of a broad undulating hill. The limestone of the neighborhood dips southeast. East of Trexlerstown, on the back of a broad ridge, and within a quarter of a mile, are five ore pits; three of these are the property of Mr. S. Albright, one belongs to Mr. Schmoyer, and one to Mr. Yoder. The ore is obtained by stripping and washing the surface earth. It is a brown hematite in small fragments. The deposit is underlaid by limestone, but the rock does not crop out at the surface, nor have the excavations penetrated to it. The ore from these mines, and from Trexler's pit, is delivered to the Thomas iron furnaces at Hokendaqua. On Samuel Albright's land, one mile southwest of Trexlerstown, a similar deposit to those above mentioned is found. None of the ore deposits last referred to furnish any local evidences of their origin.

The Saucon Mines, the most extensively wrought for ore in the district now under consideration, are situated three miles southwest of Hellertown, on the county line of Lehigh and Northampton, near the Saucon creek. They are within the limestone valley of the Saucon, which is bordered by the ridges of the South Mountains, known as the Lehigh Hills. These mines, the property of Messrs. Bahl and Gangware, consists of two pits, one a narrow excavation 250 feet long and 30 feet deep, the other a somewhat circular and shallow pit. In both mines red hematite ore is found imtermixed with the brown, the former in irregular nodules, the latter stratified, particularly in the long pit known as Bahl's. The two varieties are found in about equal proportions in this pit, the former usually scattered through blood-red and pink clays, the latter alternating with many-colored clays, from grey to dark brown. Most of the ore obtained from Gangware's (circular) pit is of the red hematite variety, but it is probable the brown ore will be found abundant when the excavation has penetrated deeper. There is no uniformity in the bedding of the ore in this pit, whereas in Bahl's the stratification has a quite regular southeast inclination. A shaft sunk in Bahl's pit to a depth of 60 feet did not reach the bottom of the ore deposit, but in other places within a hundred yards, mine shafts from 40 to 70 feet deep encountered nothing but clay. It would therefore appear to be a purely local deposit or nest of ore, in which the materials have been laid down with some regularity. Northwest of Bahl's mine, within 200 yards, limestone crops out, and dips gently towards the mine. One or two smaller excavations have been made within a hundred yards southeast of Gangware's, but they have not led to any very promising results. In one a small amount of dull brown ore was found, in the other nothing but sand and pebbles, and masses of undecomposed sandy rock. In Bahl's and Gangware's pits, fragments of rock are found undecomposed, chiefly a cherty material of greyish-blue color and flinty texture. In the latter pit a large amount of this is found, but it was too nearly covered to admit of any conclusion respecting its true place or its dip. The yield of these mines is 15,000 tons per annum. The ore is delivered to the Thomas iron works.

Moselem Mine, Berks county, 6 miles west-southwest of Kutztown. At this locality there are two pits, an eastern and a western, 200 yards asunder, situated in a nar-

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row valley between a conspicuous slate-ridge and a lower limestone hill, in both of which the dip is northwest, the limestone passing under the slate. The east mine is wrought chiefly for the supply of the furnaces of Seyfert, M'Manus & Co., at Reading. The surface excavation is not large, and the ore is found in confused and irregular bunches of a few inches thickness up to twenty feet; it is intermixed with clay and earth. The ore is now obtained, in great measure, from a series of gangways diverging from a shaft at a depth of 120 feet. The ore is a brown compact hematite of the average quality, in lumps large and small. The annual yield of the mine is 10,000 tons of ore, raised at a cost of $1 50 per ton. The west mine is exclusively an open pit, excavated 80 feet deep over half an acre. The ore is delivered to the Leesport furnaces, nine miles above Reading. As at the former mine, the ore is found in irregular nests, and requires to be excavated and washed before it is fit for the furnaces. Yield 12,000 tons per annum; cost of mining $1 30 per ton under ordinary circumstances. In both of these mines, but especially the latter, many fragments of slate and cherty limestone are found only partially converted into ore.

Jefferson Ore-bank, five miles northwest of Reading, worked by Eckert and Brother. This locality of brown hematitie ore is situated on the east side of a hill of the Matinal slate formation, which occupies a position within the general valley of the Auroral limestone. The ore-deposit lies within 300 yards of a narrow dyke of trap, which ranges northeast and southwest through a considerable distance. The general bedding of the mass dips west, or under the hill, at an angle of 30°. In thickness it varies from $2\frac{1}{2}$ to 15 feet, and is underlaid at the outcrop by about 10 feet of clay, beneath which the limestone is in place. In other parts of the mine the ore is in immediate contact with the rugged floor of outcropping limestone. The pit is an open cut, stripping the surface materials from the ore stratum. The extreme depth of the mine is 63 feet, and the ore has been mined along the outcrop for 150 yards. A large amount of ore has been obtained in the lower ground, the surface materials of which are washed. Black oxide of manganese is found as a thin stratum, sometimes six inches thick in the clay, one and a half feet above the ore. Yield of ore per annum about 3,000 tons.

West of the Susquehanna $2\frac{1}{2}$ miles from the Harrisburg bridge Gorgas's large ore bank shows clay and bunches of irregular veins dipping irregularly with the underlying limestone II. The Carlisle ironworks get ore along the northern slope and at the base of the Potsdam (primal) sandstone ridges I. near the junction. While the mountain ore is cold-short from manganese the limestone or pipe ore is a little red-short from sulphur, and a mixture makes neutral or forge iron. The ore from the mountain is both compact and cellular. The valley or limestone ore bed two miles north-northwest of the works is a layer of pipe ore 8 feet thick. Other deposits occur along the Hanover road and towards Carlisle. One Holly furnace bank is four miles south of Carlisle; another Cumberland furnace bank lies between the mountain and the creek at Peffer's, and yields a manganesian pipe ore; ore is abundant along the foot of the moun-

tain near the primal sandstone. The principal Cumberland furnace banks lay three miles southwest of it near the foot of the mountain. A quarry 50 feet deep shows layers and bunches and scattered balls, thickest near the bottom. This ore was mixed with that of a bank (on limestone) two miles north of the furnace. Pond furnace at the head of Yellow Breeches creek smelted ore from the primal slates situated like the Chestnut hill ore. Mary Ann and Augusta furnaces, three miles west of the Pond close to the foot of the mountain three miles southeast of Shippensburg get ore from the Helm bank at the steep northeast dipping junction of the limestone and slate, and from the Clippenger pipe ore bank in limestone. Wherever in the valley the ore is found in red clay between the outcrop irregularities of the limestone it is of a superior, stalactitic character. Whereas the ore from the lower junction of the limestone with the primal slates at the base of the mountain is only fit for foundry purposes unless mixed with pipe ore. The two Southampton furnaces four miles south of Shippensburg were supplied with mountain ore from the Hill bank close by, cold-short above and honeycomb better ore underneath, making foundry iron with hot blast in the upper furnace; and with limestone ore from the Kressler and Railroad banks one and four miles west. At Kressler's old bank the nests and layers in soil and rotten slate dip with the limestone strata under and beside them. The Railroad bank was abandoned on account of water and the running out of the ore which lay in bunches against a limestone ridge on the north. Three and a half miles from Shippensburg Pilgrim bank lies near the northern margin of the Limestone II (near the slates of III), and other deposits of good forge iron ore were wrought at the old Roxbury bank one and a half miles west of Shippensburg and elsewhere. A fine pipe ore, wagoned eight miles to Caledonia furnace, was got two miles southeast of Green village from bunches in strings dipping with and between two ridge outcrops of limestone. This furnace is supplied from a belt of ore ground over the lower junction of the Limestone II with the sandstone of I at the foot of the ridges facing the South mountains on the west. The Pond iron banks three miles from Caledonia works show the ore in slates between the limestone and sandstone, in nests and irregular layers in a ferruginous soil, much of it in hollow kidney balls. A little further south Montalto fur-

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nace used to get a poor ore from just over the sandstone; and from the Hiefner bank a little further from the mountain, a crumbly, cold-short, very fusible ore, overlying limestone. West of the line of ore ground just mentioned is another of very cold-short pipe ore on a limestone ridge where limestone joins an intercalated bed of silicious slate and sandstone. Montalto furnace is near the foot of the outer sandstone ridge (No. I Potsdam-Primal) and upon an extraordinary exhibition of the I+II ores which are everywhere to be detected at the foot of the South mountain from the Susquehanna to Maryland, but are here more than usually abundant along the same from the Pond Bank to a point two or three miles southwest of the furnace. The ore occurs in nests in the loose mountain soil, the lower parts of these great deposits being the purest, but none being very rich. In one of the deepest diggings limestone was struck, showing that the deposits are inside the formation No. II. On the other hand the II+III ore is seen in the old Mount Pleasant furnace bank four miles west of Loudon, ranging along the west edge of the great valley, near the contact of the Limestone (II) and Slate (III)—an iridescent cold-short ore, and a better honeycomb ore, with a little pipe ore. It is obtained in abundance north of old Carrick furnace. A red-short *arsenical* ore was once got from a bank four miles northeast of Mercersburg on or near the anticlinal limestone (II) axis which parts the slate (III).[1]

Carlisle furnace (E 70) gets its brown hematite from beds three miles south of Boiling Springs; Chestnut grove (E 69) from beds five miles north; Holly (E 71) six miles south of Carlisle and now torn down, used banks on its estates, one 300 yards north, the other six miles south of the stack. Pine grove (E 72) 14 miles southwest of Carlisle has its own banks 500 yards distant, overlying limestone and covering 1,200 acres, 50 feet deep as worked and left a solid bottom. Pig pond (E 73) has beds one mile west. Cumberland (E 74) now torn down used the Peach-orchard bed three miles west, McCullough's and Goodpart's two miles northwest and Lee's five miles north. Caledonia (E 75) has beds two miles south of the Baltimore-Chambersburg turnpike, four miles southwest of the stack and nine from Chambersburg. Mount Alto (E 76) has its four banks of brown hematite within 300 yards southeast and mixes with it $\frac{1}{4}$ ore from over the limestone two miles north-northeast.[2]

Carrick furnace (E 77) in the mountains northwest of Chambersburg uses fossil ore, but Valley (E 78) uses a cold-short brown hematite from a bed four miles north of it. Franklin furnace (E 79) used Beaver's bank ore near Loudon, and also ore from a bank one and a half miles north of the stack. The Warren furnace (E 80) although in Pennsylvania, belongs topographically to Maryland and mixes its fossil ore with brown hematite from Baltimore and the Point of Rocks on the Potomac.[3]

[1] Final Report, pp. 262–270. [2] Bulletin Amer. Iron Association. 1858. [3] Ibid.

An apparently III+IV ore occurs in the **Path Valley** fault (west of Loudon and Chambersburg) at the old banks of the old Mount Pleasant furnace; crushed slate and ore lie in the fault where the Sandstone IV is thrown down against the upper part of the Slate III (see Henderson's section in Final Report, p. 320). All the ore in Path valley is along this line of fault and perhaps derives in this case, as Henderson supposes, from the loose crushed ferruginous sandstone by mechanical precipitation against the impervious slate. But at the Carrick furnace bank, on the fault west of Fannetsburg, a row of sinkholes marks the line of fault and the ore has been caught in clay against the face of *limestone.* And while sometimes good exposures of the fault may be obtained without a sign of ore, the ore abounds along the fault for seven or eight miles west of Fannetsburg, in immense quantities. The large mass of clay above the ore is tough and black and full of *sulphuret* of iron; the ore itself *dips with the limestone* and is nearly 30 feet thick at the surface and thins to a wedge below. To the southwest the ore is in large angular masses through the clay and the southwest surface of the valley is much strewn with such by some inundating force.[4] It is evident from these facts that the ore is a decomposition from sulphuret of iron in a bed of slate lying between or upon limestone and suffering less and less from the action of the decomposing agent (the moisture of the air) the further it descends. It is probable therefore that the ore in old Mount Pleasant bank mentioned above came from some such ferruginous slate bed caught in the lips of the fault, and not from the sand-stone.

In McConnellsburg Cove in the southeast part of Fulton county a fault sends down the Lower Silurian Limestone II northwest against Devonian Sandstone VIII. Hanover ore bank lies in the fault where the lower edge of the Slates III go down into the fault.[5]

In Blacklog anticlinal Lower Silurian slate (III) **valley** splits along the middle by a belt of limestone (II) no iron ore appears; but apparently in a fissure of one of its bounding mountains, on the summit of Blacklog, 4 miles southwest of Orbisonia a deposit of cellular hydrated peroxide, in stalactitic masses, in clay, in white sandstone (IV) was once dug for Rockhill furnace. Meadow gap shows traces of the same.

[4] Final Report, vol. i. p. 322, [5] Repeated on page 479 of Final Report.

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In Kishicoquilis, Nittany, Morrison and other valleys between the lower Juniata and the Alleghany mountain examined with great skill by Mr. McKinley and Dr. Jackson the brown hematites are distinctly traced to the ferruginous sandstone strata, harsh to the touch on the weathered surfaces, and covered with an ochreous soil,[6] intercalated in the lower silurian magnesian (auroral) limestone formation No. II, which forms the valley floor, and through which the Potsdam (primal) slates and sandstones No. I never rise high enough to appear. It was the opinion of some of the gentlemen of the survey, Professor Frazer among others, and perhaps still is, that these deposits of iron ore come from the disintegration of the sometimes ferruginous sandstones of IV in the bounding mountains. But this theory, however supported by appearance, involves the errors of a diluvial theory or tertiary theory, and is otherwise set aside by the presence of the same kind of deposits along the outcrop of the same limestones (No. II) on the south side of the great valley many miles across from the nearest outcrop of the sandstones No. IV. The formation is subdivided by Mr. Rogers in this region into three groups, the uppermost Matinal limestone, an upper Auroral fossiliferous (Black river, New York survey) group, and a lower Auroral nonfossiliferous, magnesian, group; thus, descending:

a.	Matinal dark blue carboniferous limestone with Orthoceras pressum, Lingular trentonensis, Isotelas gigas, alternating with light blue thin very fossiliferous beds, ...	500 feet.
b.	Encrinal and coralline, thin bedded, . . .	30 "
	Blue, massive, fine, with coral cast-holes, . .	20 "
	Birdseye Limestone (N. Y.), Cytherina, blue, fine,	150 "
	Blue, thin, fossiliferous, sparry; coral cast-holes,	400 "
c.	Blue clay limestone and grey coralline magnesian,	200 "
	Nonfossiliferous massive light blue magnesian, .	500 "
	Coralline light blue and dark grey—alternating,	1,000 "
	Slightly fossiliferous light blue limestone, . .	300 "
	Nonfossiliferous grey magnesian crystalline, .	1,500 "
	Nonfossiliferous light blue magnesian limestone, .	700 "
	Nonfoss. grey mag. crystalline, exposed for .	600 "
	Total thickness of II exhibited about .	6,000 "

[6] Rogers's Final Report, vol. i. p. 470.

The slates of III (Utica and Hudson) are about 1,400 feet thick in Kishicoquilis and 1,000 in Nittany valleys.

Mr. Rogers says on page 479 Final Report 1858, that the ores "having generally no very close relation to the rocks beneath, their discovery is rather empirical." Yet in the next sentence he excepts those of Kishicoquilis valley where "the distribution is so dependent on the geological structure that its range can be determined with scientific accuracy. All the ore deposits hitherto mined lie over the anticlinal lines of the strata, in the fissures produced by their abrupt bending at the time of their original elevation." These lines are four in number; in the principal one near and parallel to the base of Stone mountain the rocks are overturned to the northwest. Two shorter axes lie southeast of its southwest extremity, on the northwestern of which is situated Davis's pipe ore bank, exhausted before 1838, having sent 800 tons of perpendicularly arranged stalactites to Greenwood furnace. A fourth axis, commencing three miles southwest of Brown's gap becomes the main axis of the southwest end of the valley and holds Holliday's bank, near the mill east of Greenwood; the limestones dip adversely on opposite walls of the quarry; fluor spar occurs here in small quantities, and is so far forth evidence of a volcanic origin of the iron, or supports so far the exhalation theory. The old Hall and Rawle bank is also exactly on the axis one mile southeast of Greenwood; long worked; ore sometimes in pure mass, and at 70 feet depth a solid bed of great thickness; stalactitic; irregular. Brookland furnace bank a mile further along the axis.[7] If however the line of crust-break had anything more to do with the origination of the ore than the bringing to the surface the proper ferruginous strata and providing receptacles for the decomposing mud, or pools of tepid water in which the mud might collect to decompose, we ought to hear of a line of banks the whole length of all these four axes. And if hot springs were the prime operators, why have they ceased to flow, and why do not the hot springs of Virginia deposit now brown hematite in mass? It is much more probable that the deposits occur where certain layers originally charged with sulphuret of iron (?) have been brought to the day along these anticlinal crevices and suffered decomposition at their broken edges, a part of the precipitation being pre-

[7] Final Report, p. 479.

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served to us in the wider, deeper and therefore worse drained portions of the crevices open to the air. In support of this view we have seen that in the McConnell's cove no ore is found along the axis, but an impure clay iron stone is found scattered on the lower limestone; and the Hanover ore bank is found in the slates of III. In the narrow anticlinal valleys of the Seven Mountains or the Buffalo mountains, Sugar valley etc. the lowest limestones of II are not brought up and therefore no great deposits of brown hematite have ever been discovered.

Nippenose valley has never yielded brown hematite banks; its limestone surface is rough and its clays shallow. Mr. Rogers explains the absence by the gentleness of the dips and the consequent rarity of longitudinal fractures, but it can be explained better by another consequence, to wit, the suppression of the base of the formation (the true iron-bearing formation) beneath the surface.

Sugar valley with its steep and even overturned dips[8] on the contrary brings up the base rocks of II and therefore has iron ore beds three miles west of Kleckner's and elsewhere but of no great value, the surface being strewed with good brown ore and chert. Shafts sunk near Friedly's old furnace 30 feet deep struck rock at 15 and found no ore.

Brush valley has yielded no ore of any consequence except as surface fragments. Although its rocks are 80° steep on the northern side, it is narrow and its anticlinal probably does not bring up the ferruginous layers because it has not been broken.

Penn's valley with its offshoot at the upper end, George's valley, has gentle dips and therefore no iron ore deposits.

Nittany valley into which Penn's valley opens up southwest is from 2 to 5½ miles wide and therefore the lowest rocks of II have a fair surface field and form the range of "Barrens" destitute of water and containing vast accumulations of rich iron ore. Two miles east of Bellefonte they begin to form a central ridge or deeply grooved highland, beset with outcrops of impure limestone, and terminating 5 miles southeast of Millhall gap. The northern dips being as high as 70° where the anticlinal flexure is the strongest there is abundant room in so wide a valley for the upcoming of the lower layers of the lower silurian limestone

[8] See McKinley's section on page 491 of Rogers's Final Report, vol. i.

formation in this central ridge,—sandstones and silicious limestones, dipping 60° north 25° west opposite Millhall, and under them a fine conchoidal pale blue sandstone, "very persistent throughout this and all the neighboring Matinal valleys," and of great thickness, a few of its beds being somewhat calcareous. Half a mile east of Salona it dips 5° north at the ore diggings.[9] It is evident that with such a dip no anticlinal or emanation hypothesis is applicable to the explanation of the ore; this must originate from the rocks brought up to surface, and all the banks are stated by Jackson in the Final Report to be in proximity to the impure limestone beds called Curly-back, some at the south foot of the ridge and some on its broad summit.[1] The crest of the anticlinal seems to be absolutely horizontal three miles southwest of Salona. At the Washington ore banks 2½ miles across the barrens from the furnace, the ore *and* limestone dip 45° south, and further on stand vertical or overturned. In fact he recognizes in so many words the fact that "there seems to be a fixed relation between the ore and the part of the formation, or the character of the rocks lifted to the surface of the flexure, and between it and the ferruginous earth which itself is dependent on the extent of deposition during denudation." The last part of this sentence seems to be an addition by Mr. Rogers, although there is no way to decide such a question, since Mr. Rogers indorses *en masse* as his own discoveries all the facts of the survey and therefore becomes responsible for all mistakes, as well as the innocent cause of the curious want of harmony and symmetry which characterizes the Final Report. If the suggestion made above be correct, it shows how poorly the diluvial denudation theory of Mr. Rogers qualified him for appropriating the heterogeneous masses of observations made by the other members of the Pennsylvania state survey; for Dr. Jackson here saw only the natural drainage weathering of the exposed strata into pits where chemical changes deposited the ore; but Mr. Rogers sees the rush of the ocean down from the Alleghanies, and the worlds of sand and muddy debris that it left behind. It is a little singular that Mr. Rogers with this clear statement of Jackson's in his possession could not apply it to the Great Valley range of ore beds where it has so immense a sweep, and might have found so precise a geological determina-

[9] Jackson in the Final Report, page 495. [1] Page 499.

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tion. Perhaps the promised chapter on iron ores in the second volume of the Final Report when it appears will explain the cause.

The Salona banks showed cellular ore *mixed with much sulphuret of iron.* The Washington banks opened at least as early as 1828, show two seams of pipe ore and a third of inferior quality dipping 40° with the silicious limestone curly-back. The Lamar and Beck banks continue the range. The old Harris bank near Jacksonville yielded in 1838 40 tons of good pipe ore per day, by a shaft 25 feet deep through white and yellow clay, the vein of ore pitching steeply north. A neighboring shaft went down 100 feet through clay to strike the ore, getting occasional stalactites 3 feet long; no limestone bottom; the situation was between two sharp anticlinals. John Beck's shafts 50 feet deep through massive white-grained sandy limestone struck good pipe ore dipping 30° southeast. Harris's shaft two miles northeast of Hecla furnace went down through red sand 8 feet and white clay 12 to fine brown gravel ore lying on solid pipe ore dipping 45° north; two drifts a hundred feet long were run horizontally in the fine ore (in 1838?) The neighboring Hecla bank had supplied two furnaces twelve years, in 1838, and was 200 feet long by 40 deep, the pipe ore veins from 2 to 5 feet thick irregularly bedded in ferruginous loam, with occasional patches of red oxide, and an argillaceous oxide in alternate layers brown and yellow, while masses of black clay colored with vegetable matter were seen in the white clay.[3] McKinney's bank opposite the Hecla furnace yielded ore within 2 feet of the surface; one shaft went down through clay 3 feet, ore 22, white clay and sand 20 feet; some was brown oxide; some in oblong balls, filled with pure clay or water and lined with black shining oxide, of this there were 4 feet; the whole dipped north, apparently towards a synclinal. Curtis's and Gatesburg banks towards Bellefonte, and Valentine's on the hill back of the furnace southwest of Bellefonte yield pipe ore; the last between strata of sandy limestone in a cavity 16 feet wide by 60 long, lined with stalagmites, and reached by a blasted shafting 150 feet deep. Lamborn's bank sent inferior ore to Juliana furnace to mix with hollow ball ore from the Pond bank, on the barren ridge, 2½ miles southwest of Williams's. Edmonson's shaft 70

[3] Compare the Brandon lignite bed.

feet deep near Williams's on the north side of the barrens yielded pipe ore 6 to 8 feet thick between solid sandy limestone under loose rock, with 30 to 40 feet of red clay over all. Beneath the ore, limestone strata inclosing veins of ore were followed vertically down at least 70 feet more.[4]

In 1858 Washington furnace (E 113) gets brown hematite pipe ore "in a solid vein 10 feet thick" from two banks one and three miles northwest of itself, four and six miles distant from Howard furnace and eight from Flemington.—Howard (E 114) has mines three and five miles southeast, nests of limonite from 15 to 80 feet deep, usually 40 to 60, in basins on each side of the central ridge of the valley, which is two and a half miles wide. "The veins of pipe ore accompany the limestone in inexhaustible quantities, but are often abandoned from following the limestone, while the brown hematite rarely interferes with it."—Hecla furnace (E 115) in Logan gap gets brown hematite and pipe ore from every part of the central ridge 1½ miles north of it, but the deposits are "irregular and unreliable, few of them lasting longer than a single blast of nine or ten months."—Eagle furnace (E 116) on the canal, gets pipe ore from the Central Barrens 3 miles southeast of Bellefonte.—Logan furnace (E 117) has "nests" of ore in the limestone 2½ miles east of it.—Rock furnace (E 118) gets its ore from pipe banks 8 miles on the road to and 1½ miles from Pine grove; 10 miles east of Path valley; 9 miles north, in Bald Eagle valley (ore of Upper Silurian VI—not II); one mile east; and two or three others from half to three-quarter mile distant in Spring creek valley.—Centre furnace (E 119) banks are 3 miles northwest and 7 west; has pipe ore 1 mile north.—Juliana furnace (E 120) gets cold-short Lambenn bank ore from 3 miles south on Buffalo run, and red-short River hill bank ore from 4½ miles south in the barrens.—Martha furnace (E 121) is said to use *carbonate* ore from mines 4 to 5 miles southeast of the furnace.—Hannah furnace, stopped in 1851, had banks 3, 4 and 5 miles east-southeast and 6 miles east along the south foot of the Bald Eagle mountain, that is between II and III, and in Warrior Mark valley 3 miles south-southeast (these directions are undoubtedly wrongly given).—Monroe furnace (E 122) does not use brown hematite.—Huntingdon furnace (E 123) gets hers from 1½ and 4 miles north, 1, 1¼ and 1¾ miles north of west, and 4 miles northeast; "many of the banks could be opened and worked if necessary."—Pennsylvania furnace (E 124) uses a bank a mile northeast of it.—Bald Eagle (E 132) uses a bank 2¾ miles southeast.—Etna furnace (E 133) has ore lands 2 to 4 miles west of it, and mixes fossil ore from an opening 5 to 7 miles distant.—Elizabeth furnace (E 134) in Logan's valley has a bank one mile south in a limestone cove at the northeast foot of a lime ridge the top of which is sandstone, and ore and limestone stand vertical, the ore 3 to 30 feet wide, opened 100 yards long and 100 feet deep. Here we have evidence of the limestone genesis of the brown hematite, but the rocks are here Upper not Lower Silurian; the hill extends southwest to Baker's great ore bank, which feeds Alleghany furnace (E 136) 1½ miles south of Altoona. This bank is one of the finest in the country, between one and two hundred yards long and 100 feet deep, cut out of the south side of an Upper Silurian limestone ridge (No. VI) facing the Bald Eagle mountain, four miles northeast of the furnace (three miles from Altoona) and nearly opposite Blair furnace which sometimes mixes its ore with its own fossil ore. The irregular nest structure of the deposits may be

[4] Final Report, vol. i. p. 500.

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here well studied; no appearance of vertical stratification, or of any other, except an obscure horizontal one; but a sudden termination of the ore sidewise which lends probability in this instance to the theory of thermal spring deposit. It is however connected as in all other instances with limestone and loose calciferous sand rock, the disintegration of which has set free the brown ore and afforded the accompanying sands and clays. (Bull. A. I. Ass. 1857.)

On the Upper Juniata the lowest (Auroral) Lower Silurian No. II limestones occupy the barren ridge centre of the valley, a range of sandhills strewn with sandstones, dark grey sandy limestones, iron stones, iron ore and rugged cellular quartz; and southeast of Stormstown or Walkersville the anticlinal brings up the very floor of the Palæozoic system No. I, the Potsdam or Primal Sandstone. Here then come up the very rocks which follow the north foot of the South mountain, and therefore the brown hematite deposits appear with them likewise. The sandstone has been driven up by the fracture of the arch as it passes Birmingham and the upward slip of its western side, bringing up the top sandstones of I against the bottom slates of III. (Matinal black slates of Rogers.)

Canoe valley (Nittany valley continued southwestward) con tinues its "barrens" across the Juniata, into Morrison's cove, where they form a double ridge with the ore exhibited in the northern ridge overturned. In this cove Springfield furnace (E 143) has its brown ore banks two miles southeast.—Bloomfield furnace (E 145) has a bank a mile east with 40 per cent ore from 10 to 40 feet thick, costing 75 cents to raise.—Sarah furnace (E 145) has "more than a hundred banks, but only wrought in two places, both 3½ miles east, at Bloomfield furnace." It mixes a little fossil ore from three-quarters of a mile southeast.—Jackson describes the ore deposit of brown hematite around and southwest of Williamsburg on the Juniata, as extraordinarily fine. (Bulletin Amer. I. Ass. 1857.)

Milliken's Cove has no iron ore deposits, because only the top rocks of II (Matinal limestone) are exposed here and there along the anticlinal, which however has vertical dips on one side.[5]

In **Harford county, Maryland,** large deposits of brown hematite iron ore on Hope's land at the head of Howard's run,

[5] F. R., p. 511.

supply La Grange furnace on Deer creek. The iron made is of superior quality, and used for gun-barrels. They seem to overlie limestone at a considerable depth.[6] The La Grange Iron works, in Harford county Maryland, get their brown hematite, yielding 50 per cent and making good bar iron, from Hope's and other banks in the upper part of the county.[7]

The **Point of Rocks** brown hematite ore beds, and those near Sykesville, have been discussed above, pages 444, 445, in their connection with the primary ore veins.

In **Washington county,** Maryland, the beds of brown hematite formerly fed three furnaces, of which but one (Antietam) remained in operation in 1840, supplied from the deposits of the ore in Virginia six miles above Harper's Ferry, and in Maryland two miles above the Ferry.[8]

In **Frederick county,** Maryland, within a mile of Fredericton, there is a great sand quarry, where the inhabitants procure their building sand. It is a mass of calcareous sand lying apparently on a water-worn surface of the blue limestone of the valley, but when carefully examined at proper spots, is seen to pass so gradually into a compact calcareous sandstone or sandy limestone that no doubt can remain as to its being a disintegration of the rock through the slow lapse of time by chemical reagents. Within it are small veins or seams of brown hematite ore, no doubt in their original position before the reduction of the rock to sand.[9]

The Catoctin furnace north of Frederickton Maryland stands at the eastern base of a talcose slate mountain, against which repose Lower Silurian limestone and New Red sandstone and shale, with its celebrated building breccia outcropping along the edge of the valley. Here are extensive beds of argillaceous oxide of iron, underlying blue clay containing nodules of phosphate of iron and brown ochre, with a notable percentage of carbonate of zinc. The zinc fumes line the furnace with a crust that has to be removed, and from which zinc has been made with ease, and used in the manufacture of the United States standard brass weights. Other deposits of brown hematite are known but not wrought along the valley, as for example at McPherson's near the Monocacy, and at places approaching the

[6] Ducatel, 1839, p. 42.
[7] Ducatel, 1838, p. 5.
[8] Ducatel, 1840, p 50.
[9] Ducatel, 1839, p 13.

Maryland.

Potomac. Large excavations show that in ancient times much ore has been take out on the road to Jefferson and the Point of Rocks at the eastern foot of Catoctin ridge, where the argillaceous oxide and the brown hematite ores are mixed. Pieces of the latter and the red variety are frequently met with on the Linganore hills to the east of this. Ferruginous oxide of manganese shows itself in the same region.[1]

In **Carroll county** a furnace at the head of Little Pipe creek, north of Unionville, once ran on a deposit of argillaceous oxide of iron on its own premises; and another deposit north of Manchester once supplied a furnace in Pennsylvania. Ferruginous oxide of manganese appears two miles east of Westminster.[2]

Virginia, says Whitney, like Maryland and North Carolina, "possesses inexhaustible supplies of iron ore, which are mostly the hydrous peroxide of iron." Brown hematite ore deposits are occasionally seen at the junction of Potsdam Sandstone No. I, and the Limestone No. II, sometimes of good quality, but often blended with oxide of manganese.[3] Brown hematite, compact, earthy, cellular and pipe ores occur in Limestone No. II, especially in the southwestern counties of the Great valley of Virginia.[4] Iron pyrites is of very common occurrence in the slates of No. III in Virginia, giving origin to the sulphurous springs like those of Shannondale and Winchester.[5] It is also common in the black fossil slates of VIII,[6] disintegrates it and covers its surface with sulphate of alumina. In fact the principal iron banks of the Great valley of Virginia repose not on the Limestone II but on the Slate III, near or at its junction with the Sandstone IV, as in the Big and Little Fort valleys of the Massanutten range of the Blue Ridge.[7] The deposits are very large, almost always manganesian, but make excellent iron.

Taking the investigations of the American Iron Association[8] in 1857 and 1858 as the only guide we have, and the counties along the Great Lower Silurian Winchester valley in their

[1] Ducatel, 1839, p. 33.
[2] Ducatel, 1839, p. 34.
[3] W. B. Rogers's Second Rept., p. 60.
[4] Same, p. 66.
[5] W. B. Rogers's Second Rept., p. 67.
[6] Same, p. 76.
[7] Same, pp. 46, 69.
[8] Bulletin, p. 112.

order southward, we have the following facts, reducible to any map by referring first to the location of the furnaces given in Part I Table H.

Jefferson county; Shannondale furnace (H 170) has beds of brown hematite 300 yards from the Potomac 1½ miles below; half a mile from the river a mile above; and half a mile northwest across the river.

Frederick county; Taylor furnace (H 171) stands 10 miles west of Winchester, but its mines are not mentioned. Zane furnace on Cedar creek is a ruin, abandoned thirty years ago.

Hampshire county; Vulcan furnace (H 174) used fossil ore, but will hereafter use coal measure carbonate. Bloomary furnace uses brown hematite. McCarty's has not blown for thirty years.

Hardy county; Capon furnace (H 176) on the Cacapon river at the turnpike crossing, has red-short brown ore less than two miles west, "in a regular bed, six feet wide of unknown depth." Bryan's and Trout Run furnaces are both in ruins.

Warren county; Fort furnace (H 179) or Elizabeth, on Passage creek, uses porous brown ore from a bank 300 yards west.

Shenandoah county; Columbia, Caroline and Liberty furnaces are running, but three others make nothing. Paddy furnace (H 180) gets cold-short brown ore one mile west and one mile southwest, with some bog ore three-quarters of a mile due west, in which bog lie stumps and roots of trees, and a coffin and human body, all turned to ore were exhumed from it.—Columbia furnace (H 181) gets 45 per cent brown hematite from Five-mile bank, five miles northwest; 50 per cent ore from Three-mile bank southwest; 45 per cent ore from Drummond bank two miles west, near where there was formerly a 40 per cent ore from Black-oak bank two miles west.—The Vanburen furnace (H 182) No. 1 obtained cold-short brown hematite 250 yards off, also within a mile and a half north, west and southwest.—Caroline furnace (H 184) gets a yellow and black oxide from the mountain 1¼ miles on the Luray road, and mixes with it fossil ore from 2¼ miles northwest. Liberty furnace (H 185) gets its brown ore from one mile north, although there are banks within half a mile. Its ore is 60 per cent, or 45 per cent taking strippings and all.—At Henrietta furnace (owned by S. B. & J. E. Myers & Co. Orkney Springs P.O.) a tunnel has been driven into a mass of nearly vertical ferriferous gneissoid mass 50 feet thick, above which lies (horizontally as drawn in a rude section sketch) open porous brown hematite. The rock, when analyzed by Dr. Genth of Philadelphia, contained 71.00 carbonate of iron, 4.80 carbonate of lime, 1.90 carbonate of magnesia, 13.50 silica, 6.25 alumina, 1.58 iron pyrites, no phosphoric acid. If picked of pyrites, a valuable ore, yielding raw, 35 per cent iron, and more when roasted. The existence of this massive carbonate in place beneath a surface deposit of brown hematite, tells much of the story of the great range of Lower Silurian limestone brown hematite deposits inside the Blue Ridge from Vermont to Alabama.

Page county; Isabella furnace (H 186) ore lies deep.—Catharine furnace (H 187) uses a 40 per cent ore from banks within a mile north-northwest; there is a bed of red-short ore close to the furnace not used; the ore improves along a series of banks half a mile apart for two miles southwestward; a more promising opening has been made half a mile northeast.—The Shenandoah Iron-works furnace No. 1 uses a 50 per cent (cleaned) ore from banks in Rockingham county within 250 yards of furnace No. 2, the furnaces being five miles apart.

Virginia.

Rockingham county; Shenandoah Iron-works furnace No. 2 has its banks close by.—Margaret Jane furnace (H 190) has a good ore bank a mile off, another good bank five miles to the north, and a third of rich ore at the foot of the mountain three miles north. A railroad a mile long runs to the first bank.—Oakland & Smith's creek furnaces have been long abandoned.

Augusta county; Elizabeth furnace (H 193) a new furnace on the Central railroad, has ore somewhat over a mile southwest.—Mossy creek furnace (H 194) stands a ruin surrounded by ore banks in all directions from a quarter to two miles distant.—Mt. Torry (H 195) on Back creek, has a cold-short ore bank two miles northwest.—Canada furnace (H 196) blew but a few days and is a heap of ruins.—Estilline furnace (H 197) has very rich cold-short ore two miles southeast, and pipe ore, not so rich, two and a half miles south (one and a half miles from first bank).—Cotopaxi furnace (H 198) uses Morris bank ore one mile south with some Bear bank ore 30 per cent 35 per cent three miles northeast.

Rockbridge county; Vesuvius furnace (H 199) on South river, uses Black rock (Fulton and McClung banks) 30 per cent ore one and a half miles south, which it roasts; Kelly 35 per cent easy smelted ore two and a half miles east; a richer coldshire bank ore three miles east; Old Moore (Black rock) bank ore 35 per cent three miles northeast, which makes the best metal.—Buena Vista furnace (H 200) fifteen miles further down the river uses Cash bank 33 per cent ore two and a half miles east, mixed with Hayes bank 33 per cent ore three miles southeast; Old bank 50 per cent ore over three miles southeast.—Glenwood furnace (H 201) uses 40 per cent 45 per cent Greenlee bank ore one mile north; a bank of nearly all fibrous ore, 300 yards southwest of the stack, is just at present stopped by water.—California furnace (H 202) on Bratton's run, uses a cold-short 50 per cent ore from two banks on the same vein 200 yards apart and over two miles from the stack.—The four other furnaces in the county were abandoned long ago, but whether the fault lay in their ore beds or not is not recorded.

Alleghany county; Dolly Ann furnace (H 207), called Rough and Ready once, is said to have inexhaustible brown hematite deposits at the stack.—Australia furnace (H 209) uses "$62\frac{1}{2}$ per cent" brown ore from a bank 600 yards northwest.—Clifton furnace (H 210) used last in 1854 a 50 per cent ore from banks a mile east and west.—The other two furnaces are dilapidated.

Botetourt county; Roaring run furnace (H 212), abandoned in 1854, had three banks on the estate but only used the one a mile north.—Grace furnace (H 213) uses two banks near together one mile west; mixes 50 per cent Mountain bank ore $\frac{2}{3}$ with 50 per cent Black bank ore $\frac{1}{3}$ to make high iron; uses the first alone for grey iron.—Cloverdale furnace No. 2 on Back creek, uses Fallon bank 65 per cent (best lump) 60 per cent (best fine) ore, three miles south, for gun metal; mix with Campbell bank hard 60 per cent fine 40 per cent 50 per cent ore one mile east, to make No. 2 metal; to get best gun metal mixes $\frac{3}{4}$ best fine McFarlane with $\frac{1}{4}$ hard.—Etna furnace (H 219) uses Retreat bank honeycomb ore six miles (by road, ten by railroad) north; lump ore 300 yards west.—The seven other furnaces of the county are dilapidated and gave no report of ores.

Craig county had an old furnace now gone.

Wythe county; Barrenspring furnace (H 223) uses 45 per cent brown hematite ore alloyed with lead from openings 300 and 1,000 yards southeast.—Wilkeson's furnace (H 224) gets its ore four miles west.—The other three furnaces are abandoned.

Washington county had two furnaces, now gone. (Bull. A. I. Ass.)

Having now mentioned the principal brown hematite deposits of the Great Valley of Lower Silurian Limestone and Slate, along the northwestern edge of which runs the outcrop of the fossil red hematite ore bed of the Upper Silurian Formation No. V (Clinton), it is only necessary to add that almost every one of the XII palæozoic formations in this State presents to the surface more or less extensive and regular deposits of brown ore, the consequence of the disintegration of sulphuret or carbonate of iron in the slate or limestone strata which alternate from bottom to top of the series. But few of these deposits are of any practical value, until we enter the great coal region of the western counties, where innumerable outcrops of the carbonate beds of that formation hold their peroxidated treasures in trust for the future. Only in the extreme northwestern counties of the State have these anywhere attacked. Prof. W. B. Rogers says that ore has been found in connection with formation VII (Oriskany sandstone), but that he knew nothing about it;[9] and also with formation VIII (Devonian) alloyed with manganese.[1] It is in this connection particularly unfortunate that the Virginia survey amounted to so little, because at this geological level the iron ores of Middle Pennsylvania and Middle Kentucky occur, and may be naturally expected to show themselves well developed at various points throughout this immense State, the floor of which is broken by profound faults hundreds of miles in length, reduplicating the surface outcroppings of all the palæozoic formations many times between the Great Valley on the east and the continuous outspread of the Western Coal. The Devonian rocks come up over and over again, in long narrow belts, any one of which may discover the ore of No. VIII in force.

Of a still later date is the brown hematite ore of the Richmond Coal-field, found, as Prof. Rogers says, in proximity to Trabue's pits, and analyzing: Peroxide iron 85.15, silica 4.20, alumina 4.00, water 6.50.[2]

The **Carolinas and Georgia** have their brown hematite ore beds, but so connected with the primary red hematite and magnetic ores that they were necessarily treated in the last chapter.

[9] Second Report Virginia Survey, p. 75. [2] Page 78.

[1] W. B. Rogers's First Report for 1836, Richmond 1838, p. 11.

East Tennessee continues the Great Valley of Virginia onward into Alabama, the great primary region on its left (the east) broadening southwards, as the great coal area on its right (the west) narrows in the same direction, the latter being undoubtedly a consequence of the former, in the grand operations of that power which slowly shrivelled and cracked the eastern Atlantic border of the Continent, shouldering the coal area more and more into the air above the level of denudation, and thereby bringing it to its close like the smallest synclinal coal basin of the anthracite fields. The numerous furnaces and bloomary forges of the East Tennessee Great Valley of Knoxville and Chattanooga, show how abundant are the Lower Silurian brown hematite deposits; while those along its northwestern border mark the outcrop of the Upper Silurian red hematite fossil ore of V. Troost says that the richest and purest of the brown hematite ores in the banks of Eastern Tennessee was at one time rejected by the miners under the impression that it was the Black Jack of the English, a sulphuret of zinc. Just so the carbonate of lead was thrown away among the refuse of the Wythe county mines in Virginia as white clay, until its value was made known. The railroad runs down the middle of the Great Valley and the counties lying on the left of it, are those which use the older brown hematite deposits, and these will be taken in their order going south, following, as before in Virginia, the Bulletin notes of American Iron Association collected in 1857 and 1858.

E. Tennessee.

Johnson county has but one furnace.—Ward's bloomary (I 134) No. 2 has honeycomb 25 per cent ore three miles south of it.—Wagner's three miles higher up Laurel fork of Holsten, has twenty abandoned banks in its vicinity.—Ward's forge on Roane creek uses banks half a mile and one and a half miles northeast and two miles east.—Sandhill forge one and a half miles higher up on the same creek, uses Little mountain ore two and a half miles north.—Sand Spring forge on the same creek, uses the same ore four and a half miles east, and Big mountain ore six miles east. Little mountain is a spur of Doe mountain, and although these ores are called hematite, some of them may be outcrops of primary veins, or even red hematite, but if so the fact would probably have been stated.—Dugger's on Watanga river, gets honeycomb ore from openings all along the sides of Dry run mountain to the northeast, one of which, six miles off, makes soft gun-barrel iron, the others are richer.—Murphey's two forges, a mile apart on Doe creek, use the same lump ore from Doe mountain six miles east.—Howard's two forges, a mile apart and also on Doe creek, have ore openings all round the lower forge, and also get lump ore from nine miles east. Blevin's forge on Beaver dam creek, one mile

below King's, uses honeycomb ore got three miles northwest of King's in Carter county.

Carter county; Union furnace (H 262) on Stony creek, uses Grindstaff bank ore half a mile southeast, Canaan band *red hematite* one mile northwest, and Hodge bank *brown hematite* four miles east, and there are several smaller openings not used. The bank most used has 30 to 40 feet of ore in depth, covered with 5 to 15 feet of red clay; it is hauled 75 yards to wash, and yields then 40 per cent.—No account is given of the ores used at Obrien's, White's and Rockbridge furnaces (H 265, 266, 267), abandoned.—Stonedam forge (I 348) uses fine Hodge bank ore over one mile east, fine and lump Julius bank ore one mile north, lump New bank ore over one mile southeast, Taylor bank ore three or four miles southwest; yielding 33 per cent of bar iron in blooming.—Speedwell forge ore is one and a half mile east of it.—The two Carter forges, also on Stoney creek, only the upper one running, one and a half mile below Union furnace, use the furnace pig and no ore.—Farmhall forge, on the same creek, has its brown ores close by.—Purlieu forge, on Doe river, has cold and red-short brown ores to the south and east.—Hampton's forge however is surrounded by magnetic ores.

Sullivan county; Franklin furnace (H 258) on Bigsinking creek uses $\frac{2}{3}$ Sharp-bank *red hematite* (fossil) ore five miles north, $\frac{1}{3}$ Crockett bank brown hematite ore four miles north, the mixture yielding "about 61 per cent."—Holston, Weleker, furnace (H 259) on the north bank, uses hard solid *red* hematite 70 per cent Sharp bank ore six miles northeast, 4 to 6 feet thick, wrought for 50 or 60 years (see Safford's report of 1856); sometimes Crockett bank ore, four miles northeast, "an extensive ridge of red earth with numerous small blocks of solid hematite scattered through it."—Two old furnaces are on Beaver creek.—Waterloo forge (I 360) on Beaver creek used Sharp's bank ore previous to its stopping in 1855. So does the Upper Beaver creek forge ten miles west of the bank. The lower forge is abandoned and the river bend forge blooms up pig metal.

Washington county; Pleasant Valley furnace (H 269) on the Nolichucky gets its 60 per cent 65 per cent brown hematite ore from a bank nearly 3 miles south-southwest, half a mile back from the river. "The ore runs from the furnace southwestward, into the mouth of a cove, two miles wide, and the mountains on each side have much ore."—Cherokee forge three miles north of the furnace uses Cherokee creek (brown) hematite ore. Pinegrove forge, abandoned, used Greenridge bank ore.

Green county furnace (H 271) is abandoned, but Click's, Alexander's, Mountain, Camp creek, Snapp's and Paint creek forges all use Cove creek bank and Greenridge bank ores, the former called 33 per cent and the latter 25 per cent (mixed $\frac{2}{3}$ and $\frac{1}{3}$ at Snapp's), and at the very old Camp creek forge mixed with Cavindish bank 25 per cent ore. Cove creek bank is 10 miles southwest and Greenridge bank is one and a half mile northeast of Mountain forge on the Watery fork of camp creek. Kelly's, Allen's, Canada's, and Brown's forges are deserted.

Cocke county; Legion furnace uses Cook bank "hematite and honeycomb" ore four miles north, and Meadow creek bank ore four miles south; there are many other smaller banks.

Sevier county; Pigeon forge (I 380) has brown hematite banks north-northeast and southwest of it.

Blount county; Amerine forge uses hard Pfout bank ore four miles west.—Shield's forge on Little river in Tuckaleeche cove was abandoned for want of good ore in the neighborhood.—Abram's forge once ran on 50 per cent ore from four miles north.—Cade's used a bank one mile northeast of it.

E. Tennessee.

Munroe county; Ballplay furnace (H 574) uses a 30 per cent ore, 1 mile west, in the butt of Harland mountain.—Tellico furnace, on the river, ten miles southwest of Ballplay, gets brown hematite from *twelve* banks, the principal one being two miles southwest and the rest between it and the stack, all 45 per cent ores, yielding 50 per cent in the bloomaries and 60 per cent in the furnace.

In **Alabama** brown hematite ores abound in the prolongation of the east Tennessee Lower Silurian valley far down the eastern side of the State, but they have been comparatively neglected for the red dyestone fossil ore of the Upper Silurian, to be described in the next chapter. In 1849 Whitney says eight bloomaries and two furnaces smelted these ores, the principal works being in Benton county. In 1857 Mr. Lyman found the following works in operation on the following ores:

Cherokee county, Round-mountain furnace (H 252) uses fossil ore close by.

Benton county, Polksville furnace (H 253) uses $\frac{2}{3}$ brown hematite, $\frac{1}{3}$ 43 per cent to 45 per cent "honeycomb" ore from Chalybeate springs bank two miles north and six other openings in the same neighborhood. Two bloomary forges (I 316, 317) use the same.

Talledega county, Robroy, Eagle and Maria bloomaries (I 318, 319, 320) now use Sea bank brown hematite ore six miles north by road (of Robroy), but formerly used Hooker bank cold-short ore three miles south (of Robroy) and Stockden bank very rich cold-short ore one mile north. The new Amerine forge will use Sea bank ore and a new bank ore 2 miles south of the forge. Chennebe forge, abandoned, used to use Sea bank ore and Brown bank brown hematite ore.

Shelby county, Shelby furnace (H 254) uses a very beautiful fibrous brown hematite from a ridge a mile long by half a mile wide extending northwestwardly from the furnace, the present opening being 300 yards from it, the old opening half a mile north of it. The three forges of this county refined pig metal.

Bibb county, Brantley's bloomary (I 326) runs on neighboring brown hematite ores. Stroup's uses both brown and fibrous brown hematite ores averaging 39 per cent, from its own neighborhood.

Camp's uses a brown hematite bank 300 yards south of it and

another as far east of it; used in 1851 fibrous and brown hematite from near Jas. Green's 15 miles north.—Hill's No. 2 uses Green Pond bank ore and Squire Green's bank.

Franklin county in the extreme west of the State had a furnace and still has a bloomary running on a 25 per cent brown hematite ore dug 3½ miles east of it.[3]

In **Missouri** the Lower Silurian rocks have a wide expanse and afford brown hematite ores as on their Atlantic outcrop. Swallow reports ninety (90) localities of iron ore in the counties along the line of the Pacific railroad southwest branch,[4] a survey of which is published with a map and descriptions of the mines not only of iron but of lead and other minerals.[5] Some of these are noted in the tables on pages 33, 34, 35 as specular ore, some as red hematite, some as sulphuret, some as brown hematite, and some as mixtures of these ores. In Jefferson county there are 3, in Franklin 7, in Crawford 19, in Phelps 10, in Pulaski 7, in Maries 14, in Laclede 2, in Webster 1, in Green 16, in Dade 1, in Lawrence 2, in Stone 3, in Green 1, in Osage 5. The brown hematites so marked are in Franklin county at the company's mines and in 42 T, R 2 W, sec. NE 17;—in Pulaski county T 36, R 11, sec. NE ¼ 30;—in Laclede T 36, R 14, sec. 15; in Green county T 29, R 24, sec. 24 and 25; T 27, R 24, sec. E ½ 24. But many of the others marked simply hematite are no doubt the hydrous oxide; for Swallow says:

The red and brown hematites are the most common; they occur in nearly all the counties and are found in the Ferruginous sandstone and the Magnesian limestones [Lower Silurian I and II]. One of the most valuable localities of iron was observed in the southwestern part of Green county. Large masses of *fibrous brown hematite* cover several acres in the SE ¼ of the SE ¼ of sec. 24, T 27, R 24. The bed is more than 8 feet thick in a shaft sunk in it. In the SW ¼ sec. 19, T 27, R 23, we saw another large bed of the same ore. The same excellent ore covers many acres in the NW ¼ of the same section. It also abounds in sec. 7 of the same township, and in 14 and 15, T 27, R 24. There are also large beds of this ore to the north and northeast of these localities. Some important beds of the *common brown hematite* occur at Pond springs and several other localities in Green county. In sec. 2, T 25, R 25, in Stone county large quantities were observed. Beds of lesser importance were also seen in nearly all the counties examined. . . . .

[3] Bulletin American Iron Association, Notes p. 140.

[4] Fourth Report of Progress, 1859, page 8.

[5] Geological Report of the country along the line, etc., by G. C. Swallow, State Geologist, St. Louis, 1859. 8vo.

Missouri.

Mr. Engelmann examined large masses of *brown hematite* in Laclede county near Bear creek in sec. 25, T 36, R 14. . . . . In Crawford county the varieties observed (by Dr. Shumard) are the brown hematite, specular oxide and sulphuret. . . . . *Brown hematite* is most abundant in sec. 15 and 36 commingled with pseudomorphous crystals of pyrites, chert and crystallized quartz. . . . . In Phelps county NW ¼, sec. 27, T 36, R 7, large masses of *specular* and *brown* ore abound on the surface. . . . . In Pulaski county specular ore exists, and a large deposit of *brown hematite* in NW ¼, sec. 30, T 36, R 11, in the cherty beds of the Second sandstone and Third magnesian limestone. Large masses of *brown hematite* were also observed on the hills of Bee branch in T 37, R 10. . . . . In Jefferson county northeast ¼, sec. 4, T 39, R 4 east, brown hematite masses project from the ground. . . . . Near the Webster-Green line, in sec. 18, large fragments of hematite occur in a ravine between Saccharoidal sandstone and Second Magnesian limestone. In Green county in sec. 24, 25, T 29, R 24 west, masses of *brown hematite* are found on the summit and sides of a low hill, the underlying rock at the nearest locality being Encrinital limestone. In Maries county hematite and sulphuret ore is abundant. The sulphuret is frequently changed to peroxide on the exposed surface.

The brown hematite ore of Apple creek and Iron ridge in *Missouri* is described[6] by J. D. Whitney, U. S. Geologist, as covering the top and sides of the ridge about two miles west of the Mississippi (at Birmingham 120 miles below St. Louis)—in loose, brown masses, but seemingly solid, when uncovered in the hill, in bands and layers alternating and interlacing with cherty or silicious limestone. Some are of poor quality, others richer, and all disposed in pocket deposits. A little over a mile west of the Mississippi and a mile and a half north of the furnace pure brown hematite ore covers several acres of the ridge which runs nearly north and south 150 feet above the valley of the creek, in fragments and masses, which towards the southern limit of the area become a breccia of hematite and silica, cemented by an iron paste. Towards the middle of the hill the ore is pure. When shafted on, pure ore masses were always found imbedded in fine gravel ore with a little clay, 3 or 4 feet down, then ore in place but much broken up and disintegrated, then an uneven surface of pure ore in mass looking as if the ridge was made of it for 50 feet deep, yielding at least 50 per cent. There is ore enough here to keep a number of furnaces going for half a century Mr. Whitney thinks.

The earliest attempt in Missouri, and, in all probability, in any of the States west of the Ohio, to smelt iron ore, was in 1823 or 1824; when a blast furnace was erected in Washington county, by Eversol, Perry & Ruggles, between Potosi and Caledonia. This furnace was afterwards known as Perry's old iron furnace; and from Col McIlvaine, who was well acquainted with all the operations there, I learn

[6] See Amer. R. R. Journal, p. 516, 1853.

that the ore first smelted was obtained from Clear creek, which, however, was soon discontinued, because it was believed to contain copper; and that, afterwards, four-fifths of that smelted came from near Absalom Eaton's place, and was mixed with ore brought from the Iron mountain. The ore near Mr. Eaton's is a brown hematite, apparently of a most excellent quality, and excavated from a bank on the hill-side. In connection with this blast furnace were two forges. The first bar of iron made out of pig metal in Missouri, Col. McIlvaine says, was made on Cedar creek, in May, 1825, and the first blooms were made in 1832. Though ore was abundant and easily smelted, the great expense of transportation, however, in a new and thinly-settled country, soon induced the abandonment of the enterprise. The next blast furnace was, probably, erected in 1828, by Mr. Massey, in Crawford, which has been in successful operation up to the present time; but not having been able to visit this, I defer any report upon it.[7]

In **Franklin county** there is but one iron furnace, though there is, doubtless, such an abundance of iron ore there that many furnaces could be kept constantly supplied. This furnace was formerly known by the name of the Moselle, but is now designated as the Furnace of the Franklin Iron Mining Company, and is in Township 42 N, R 1 E, sec. 14, S E ¼. The ore is found in banks, of which there are four or five now opened on the lands of the company. One of them is about fifty feet wide and twenty-seven feet high. These ridge-shaped masses, presenting no appearance of stratification, are, in general, opened, or quarried, from the side of the hill, and are found, on the other three sides, to be surrounded with magnesian limestone. The ore obtained from these banks is a brown hematite, intermixed with yellow ochre, and found, often, in mammillary and stalactitic masses. In specimens from only one of the banks did I find any iron pyrites; and in general the ore is very pure. These banks are in the second magnesian limestone, beneath which, on the creek, is visible the sandstone that underlies this member of the Lower Silurian series. The flux used is the magnesian limestone, separated from the chert which accompanies it. Ore analysis: Peroxide iron 82.94, water 13.54, silica 1.36, alumina 1.04, with no trace of sulphur or phosphorus. That from Mrs. Farrar's land gave 80.44, 11.39, 8.03, 0.79. Another compact, massive brown hematite covering the hill-sides in T 42 N. R 2 W. sec. 17, NE ½, gave 80.15, 11.11, 8.27, 0.70.[8]

The Merrimac Horseshoe bend brown hematite beds cover hundreds of acres on each side of the Merrimac river, in Franklin county Missouri. These beds of pipe ore are "from 5 to 30 feet deep, from three hundred to a thousand feet broad and from a quarter to a mile long, the ore occurring in masses of from one to five hundred cubic feet, connected with yellow ochre." The *Virginia mines* lie three

[7] Swallow's Geological Report of 1854, p. 71. [8] Swallow, page 72.

miles higher up the Merrimac, in Franklin county Missouri, 16 miles south of South point on the Missouri river.[9]

Wisconsin.

In **Wisconsin,** Tower's furnace (K 625) in the town of Marston, T 13, R. 2 E, sec. 9, 10, is a small blast furnace capable of producing about three tons of iron per day, and intended for the manufacture of stoves, castings, etc. The amount of ore is of course too small for an extensive or permanent business. "It is a hydrated brown oxide, quite pure, generally massive, but frequently stalactite and mammillary . . . . in the seams fibrous . . . . occasionally contains small pebbles of quartz intimately mixed with ore like a conglomerate . . . and will yield 45 per cent of metalliic iron. It is safe to estimate its amount as equal to a solid bed 5 feet thick over 10 acres=272,500 tons, . . . country around heavily timbered, lime, etc. convenient." The ore stretches down the hill slope on the east bank of Tower's creek, the surface being covered with fragments of ore sometimes of a ton weight, and also large fragments of sandstone, in the fissures of which are seams of ore. Shafts sunk through the ore 10 or 20 feet strike no rock in place; but the Potsdam (No. 1, Lower Silurian) sandstone rises 300 feet high upon the hills, capped with magnesian limestone. The ore has undoubtedly come from the disintegration of the crumbling white sandstone. A similar ore is seen in the La Crosse railway tunnel west of Tomah.[1]

Brown hematite ores follow the outcrops of the Upper Silurian Limestone VI and Oriskany Sandstone VII.

This Lower Helderberg Limestone as it is called in New York,[2] being always a thin formation, its beds of iron ore seldom attain any importance. The upper part of Formation VI, consisting of chert layers under the coarse sandstone VII (Oriskany), contains argillaceous iron ore, and is traversed sometimes by spar veins containing the sulphurets of lead and zinc. At the top of the chert layers is a sandy ore.[3] The soil covering the limestone is charged with brown hematite in local deposits, as at Bittenbender's near Stroudsburg Mercer county and at the

[9] Amer. R. R. J. 1846, p. 649.

[1] Daniel's Annual Geological Report, Madison, 1858.

[2] The Cliff Limestone of Ohio; once the Premedidial or Premeridian, now the Scalent Limestone of H. D. Rogers.

[3] Rogers's First Annual Report, p. 14.

west end of Montour's ridge Northumberland county, and in many places southwest of the Susquehanna.[4]

The Oriskany Sandstone,[5] VII, that geological septum or diaphragm stretched across the midst of the great Palæozoic System, covering the Silurians and basing the Devonians or Subcarboniferous formations, and marking such coast or continental changes as gave a different face to the whole North American creation, is also, as a stratum rock, too small to hold enough of iron in its original sedimentary forms, to furnish afterwards extensive brown hematite deposits. In middle Pennsylvania however some exist.

Here the ore of VII follows the outcrop of the sandstone, wherever that formation is ferruginous enough to form surface ore under the action of the atmosphere. The soft friable pale reddish sand contains at certain places bombs and shreds of segregated brown hematite ore, which strew the surface of the ground but serve no other purpose than to deceive the expectations which they raise. The Lower Helderburg Limestones No. VI (scalent), underlie it everywhere, and are oftentimes ferruginous enough to produce bog ore upon the surface, as in Schuylkill Haven,[6] and in Huntingdon county, north of Huntingdon, where it occurs in nests in the outcrop washings, and resembles in all respects the brown hematite beds of the Lower Silurian limestone outcrops.[7] Throughout that valley much good ore has been found in connection with this line of outcrop; and in Tuckahóe valley, Blair county, two miles east of Altoona, Baker's great quarry of brown hematite one of the finest in the country, occupies a neighboring position, and was described on page 586 above.

The ore of VII in Perry county is light hazel, slaty, sometimes cellular and mammillary, quite heavy, and always found at the *top layer of the formation*, but contains sometimes pebbles, and is no doubt an original deposit previous to or down from the slates of VIII which rest upon it.[8] It was once mined in,

[4] Rogers's Second An. Rep., p. 49.

[5] Rogers's Meridian Sandstone.

[6] Final Report p. 291 vol i. See also at Pinegrove, p. 293, and at Clarissa furnace p. 288.

[7] At Caspar Flecker's seven miles and at King's five miles from the forge; also at Fluke's where it is covered with yellowish clay. Final Report p. 526.

[8] Henderson in Fin. Rep. p. 351.

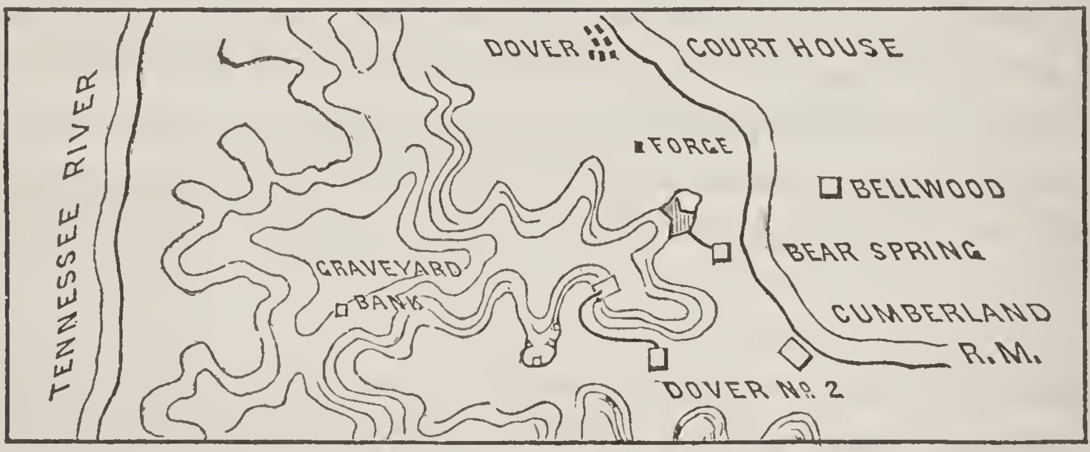
several places for Perry and Juniata furnaces 12 to 18 inches thick, lying on the upper bed of the sandstone. It extends very regularly over all that part of the country.

Further southwest where formation VII is divided into a lower slate and an upper sandstone member, the ore appears between them two feet thick, sandy and poor, apparently derived from the loose soft coarse-grained sandstone above and received in the top layers of the buff clay slate below. At Chester furnace northwest of Orbisonia the ore contains much oxide of manganese and is refractory.

In Virginia this formation has been observed to furnish unimportant deposits of coarse brown hematite. It was a shore deposit itself, as is shown by its nests of worn shells, which, when alive inhabited little nooks and miniature estuaries along its air and water line, and when dead were often rubbed quite smooth by the waves against each other or the sand. Such are quite numerous for miles south of the Potomac river in Virginia. Consequently the formation thins westward underneath the area of the coal measures, while its edge traverses New York, New Jersey and the Atlantic States to Alabama.

Here the chapter on the brown hematites ought to stop; for the carbonate ores of iron now set in, in the bottom of VIII, in XI, at the top of XI, in the coal measures, and in the Tertiaries of the sea coast. But these carbonates are changed at their outcrop edges into brown hematite; and where they are outspread quite flat over the surface, under merely a covering of diluvium or gravel and sand, the agency of carbonated rain-waters has more rapidly and thoroughly acted upon them, converting the whole formation into the hydro-peroxide, etc. In this again we see the probability that all the older Silurian and Presilurian iron ores were originally carbonates, differing from the more modern, first in having been deposited in a more troubled time and therefore not so regularly, and secondly in having been longer subjected to the oxidating agencies. In western Pennsylvania, eastern southern Ohio, eastern Kentucky and western Virginia, the hematized outcrops of the carboniferous and subcarboniferous carbonates so evidently belong to that division of the subject that they will be left for the Fourth

Chapter. But in western Kentucky and Tennessee, the subcarboniferous carbonate of iron was either the last rock deposited in that central sea before its bed rose finally to air, or was the highest rock spared when the surface was denuded to its present undulating level. It matters little to decide which. We are interested here only in the fact that over the subcarboniferous limestone in the overlying sandstone, immense deposits of carbonate of iron took place which by the agency of sulphuric and carbonic acids were concentrated, segregated into balls, and converted into a vast bed of brown hematite, the ruffled edges of which are exposed along all the ravines and subravines debouching on each side into the valleys of the Tennessee and Kentucky rivers. The Mesapotamia itself between the rivers is a flat hill ridge, say 200 feet high, with radiating spurs running down to

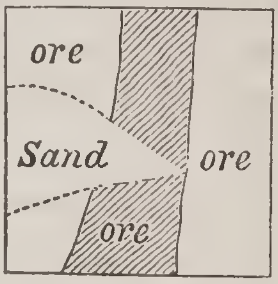


the river bottoms, and the spurs in their turn spurred or serrated on both sides. In all these spurs the ore deposit shows itself and rides the central ridge. The furnaces run their railroads or wagon tracks into open quarry-cuts which gradually penetrate and pass through the spurs, exposing from 30 to 60 feet of ore-ground in the walls of the quarry. The mining is carried in on as near a dead level as possible for the sake of draining and hauling, so that the ore is left in the bottom of the quarry and no one knows how deep it is. The ore is a mass of sand, clay and iron balls, lumps of brown and fibrous hematite, balls of flint, etc. etc. in a looser or tighter condition, finer or coarser, purer or impure, sulphurous or less sulphurous, more clayey or more flinty, as the case may be, under the possibility of a thousand variations. At Lewis's Cumberland Works one mine of splendid ore has been abandoned after a thorough trial,

W. Tennessee.

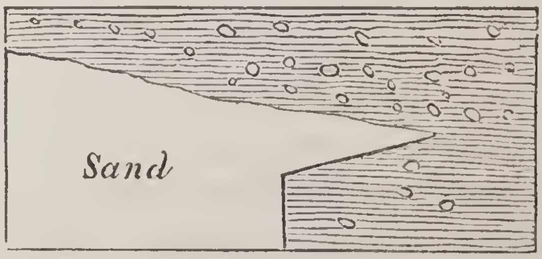
because the flint pieces were too intimately associated with the ore to be separated by any practical process. The most interesting points about these mines are the irregularity of the upper surface of the ore and the intrusion of dykes or wedges of pure sea sand[9] into the ore-ground. In the old cut at Lewis's mines, which went through one spur, the ore, all the way through the cutting, appeared above the floor in pyramids, some of which are still to be seen with blunt summits very sharply defined against the covering of sand and clay. In another cutting a *vertical* wedge of sand cut off the ore at the heading, but a little leader was seen round its point at the extreme right which led to its circumvention and a knowledge of its exact shape. In one of the mines now open a *horizontal* wedge of sand penetrates the wall in a slightly sloping posture, and when near its point fades away into ore clay. These facts seem to prove that after the great deposit was made the surface was denuded and filled with sea sand. But also that *during* the formation of the ore sea sand unadulterated with iron was dashed in by sudden violent storms or currents. If so, the iron ore must still be confined to its original position, and its present character must be simply a conversion of the carbonate into hydro-peroxide. It is remarkable that most of these deposits are of what is called pot ore, that is, hollow balls of ore, which when broken look like broken caldrons. One of them preserved by Mr. Lewis is 8 feet across the rim! Another is six feet across. The majority are crossed within by purple diaphragms or partitions of ore, and the interstitial spaces filled with yellow ochre. Some, like the great eight-foot pot, are found to

Ground plan.



Side wall face.

[9] The loose white sand-layers interstratified with clays in every formation, refuse to hold the peroxide of iron. Dr. Jackson has drawn curious forms of sand interpolations in reporting on the iron ore beds of middle Pennsylvania for the geological survey, showing how the deposits of sand and clay alternated, each new deposit being cut down or shaved off before the next of the other kind was thrown down over it. In all these cases the sand remains pure white, glittering, with crystals large enough even to break, while the clays are full of ore.



be, when broken, full of water. The inside surface is mammillary, irregular, sometimes botryoidal or knobby, but the outside is pretty smooth and regular. All these pots were undoubtedly once balls of *carbonate of lime and iron*, segregated in the original deposit. Such nodules are found in infinite numbers from western Virginia to Kansas. Most of them are cracked star-shape inside, often in marvellously regular forms. The cracks are filled with *crystallized* carbonate of lime, and carbonate of lime, and sometimes sulphate of lime. Sometimes they have cubes of sulphuret of iron or sulphuret of zinc or lead inside. Gypsum and pyrites are both of them often found in these Tennessee pots. Now Bischoff and others show that calcspar or crystallized carbonate of lime is gradually dissolved out of crevices and replaced with carbonate of iron in a crystallized form, and this again changed gradually into peroxide of iron, first hydrous and then anhydrous and then magnetic. Here we have the explanation of the septa or partitions in these pots, and in fact of all the accompanying phenomena.[1]

Troost in his 4th Annual Report 1837 page 15 says that "the silicious stratum which covers the carboniferous limestone strata and which forms all the high grounds of Middle Tennessee is the site of the inexhaustible deposits of hydroxide of iron which supplies all the iron furnaces of Tennessee with ore, those only excepted which draw their ore from the stratum of red oxide of iron on the eastern declivity of the Cumberland mountain" No. V; and he describes this silicious stratum as sometimes a sand-stone, sometimes a chert or horn-stone and sometimes an earthy rock like tripoli; as always separated from the limestones under it by a black clay schist or shale containing sulphuret of iron and coaly matter.

In western Tennessee the brown hematite beds near the Dover furnaces and Rolling Mills (K. 574, J. 207) are of great extent. All the ore banks of this region are open quarries. The ore is chiefly compact brown iron-stone, with cavities here and there filled in with brown and yellow ochre and lined with crystalline brown hematite. An average of several analyses gave Troost in 1840 Protoxide of iron 70. (= Iron 61$\frac{3}{4}$), water 12. manganese 2.5, silex 4.5, alumina 1.

The ochre yielded 54.= 42. pure iron.

A crystal of sulphate of lime two inches long was found in one of the cavities.

A small vein of earthy black oxide of manganese and yellow ochre traverses one of the Dover banks in several directions. A blackish glossy ore gave protoxide of iron 76.5 (=59$\frac{1}{2}$ iron), water 12. manganese 5. silex 4.5, alumina 1. Another gave pro. F. 80. (=62 iron), water 15. and manganese 1.

The iron bearing district of western Tennessee embraces that portion of the State lying mostly east of the Tennessee and south of the Cumberland rivers, in the counties of Harding, Wayne, Lawrence, Lewis, Perry, Decatur, Humphreys, Hickman, Benton, Dickson, Montgomery, and Stewart; the first nine of which are drained by the Tennessee and Duck rivers, while the Cumberland river in

[1] I owe this description to Joseph Lesley, Jun.

its westward course just touches the corner of Dickson and passes through Montgomery and Stewart counties until it reaches Dover C. H. where it makes an abrupt turn, and runs northwesterly, nearly parallel to and at no great distance from the Tennessee, through Kentucky, to the Ohio. This district lies entirely across the State from south to north, and is 115 miles in length by about 50 in breadth, presenting, for the most part, an undulating plain surface, much cut up by water-courses. It presents but few inducements to the agriculturist, though wood is abundant, affording a cheap fuel for the furnaces and forges. Stone-coal will, no doubt, be extensively used at some not very distant day, as a railroad is now being constructed from Memphis, through this region, to open up the large and superior coal deposits of the upper Cumberland River. The roads traversing the country are, with one or two exceptions, bad, and in the rainy seasons great inconvenience is felt in obtaining stock for the works.

"Over this whole region valuable deposits, or banks, more or less isolated, some of them of great extent, are scattered. They are found in or in good part forming many of the knobs or ridges which lie between the small branches or skirting their valleys. At many points, these ridges, extending for one, two, or, in a few cases, even three miles, are made up of deep and immense masses of flinty matter, or chert and ore mixed with clay, all resting upon a silicious or cherty limestone basis. The limestone does not always appear near the banks, being covered over by their loose masses to a depth of from fifty to two hundred feet—such being the thickness of the deposits. The ore occurs in great blocks, lumps and 'pots,' isolated, or in heaps, or in irregular veins, layers etc. from a foot to twenty or more feet in thickness, scattered at intervals through the banks of clay and chert. With the single exception of the Marion bank, near Clifton, in Wayne county, these ores all belong to one species—the brown iron ore, or limonite, comprising the compact 'honey-comb,' pot, and pipe ores and ochre—the three first being common, and found at nearly all the banks. 'Pots' often occur filled with decomposing chert, frequently with water, and a few have been noticed inclosing splendid crystals of selenite or sulphate of lime. The pipe ore is abundant at some localities in Stewart." (J. M. Stafford's Geol. Recon. of Tenn. pp. 47, 48.)

The following is an average of the results of five analyses made by Dr. Troost, from five different localities. Peroxide of iron 76.5, Oxide of Manganese 2.25, Water 13.6, Earthy matter and loss 8.1 : percentage of pure iron 53.54.

Over the region just described are scattered the furnaces named in the table, most of which, however, stand in the counties of Dickson, Montgomery, and Stewart. Of these, thirty-two are at present in full working order, though but fifteen are now running, or expect to run this year—their combined estimated yield being 17,550 tons of metal. In 1854 31 furnaces in blast, produced 37,917 tons of iron; in 1855, 27 furnaces in blast, produced 32,784 tons of iron; in 1856 26 furnaces in blast, produced 32,800 tons of iron; and in 1857 22 furnaces in blast produced 28,328 tons of iron. Charcoal is the only fuel used, and costs, delivered at the works, about $4 00 per hundred bushels (pit measure). At all the furnaces the work is performed by negroes, with but one exception (Ashland furnace), where it has been found better to employ Irish and German laborers for mining and hauling, negroes being only employed about the furnace itself. The metal made at these works is shipped by steamboat to works on the Ohio and Mississippi Rivers, or is made up into blooms at the neighboring forges, and in that shape sold mostly to the rolling mills at home and abroad.

The iron bearing district of Western Kentucky is an extension northward of the

Tennessee district, and lies to the west and east of, and between the Cumberland and Tennessee Rivers, in the counties of Calloway, Trigg, Lyon, Caldwell, Livingston and Crittenden. In it there are at present in full working order, ten furnaces, six of which are running this year, and will make about 7,500 tons of metal. There are two rolling mills, both in full operation, and three forges, one of which only is running. The amount of pig metal produced in this region from January 1854 to January 1858, was 56,700 tons—9 furnaces in 1854 making 13,300 tons; 10 in 1855, 12,300 tons; 10 in 1856, 15,500 tons; and 10 in 1857 making 15,600 tons. Here also charcoal is the only fuel employed and negro labor is preferred. Each proprietor hires on Christmas day from the surrounding plantations that number of hands which he will need for the ensuing year. The ores of the region according to analyses made by Dr. Peter, Chemist to the Kentucky Geol. Survey, yield from twenty-five to fifty per cent of iron; the earthy silicious matter varies from nine to fifty-four per cent, with usually small quantities of alumina, lime, magnesia, carbonic and phosphoric acid, and alkalies; these latter ingredients being seldom over a fraction of one per cent. (Vol. I.—Nos. 139, 142, 143.)[3]

Western Kentucky—Crittenden county—Hurricane furnace (K 551) gets its brown hematite ore from the celebrated Jackson bank nearly two miles distant.—Crittenden furnace (K 552) has ore in its neighborhood.

Livinston county—Ozeoro or Hopewell furnace (K 553) has brown hematite banks near by.

Lyon county—Underwood furnace was abandoned the year of its erection.—The Suwaunee iron-works (K 555) two and a half miles back from Cumberland river in the midst of a fine ore and timber country, gets its brown hematite from the "Iron mountain bank" three miles west of the furnace; crops out around the summit of a hill 70 feet high, and yields 50 per cent in the furnace, producing a metal "particularly adapted to the making of steel; is used in Pittsburg for that purpose, and in Cincinnati for making boiler plate." Nine hands will quarry and dig sufficient ore to make 1,600 tons of pig metal annually. During the last four years the metal has been converted into blooms at Union forge, and thence shipped by river to market. The furnace blew out last Christmas and is not now in blast. It is at this furnace that Mr. Kelly's process for refining iron in the hearth has been most fully experimented upon.—Mammoth furnace (K 557) one mile from the left bank of Cumberland river on Little Hurricane creek, has its banks from one to three-quarters of a mile west.—Fulton furnace (K 558) uses pot ore from banks in its neighborhood.

Trigg county—Centre furnace (K 559) and Empire furnace (K 560) two and a half miles east of it on the left bank of the Cumberland river, one mile above (south) the Tennessee R. M. and forge, have their own banks.—Laurel furnace (K 561) has brown hematite mostly pot ore in the vicinity.

Calloway county has one furnace (Gerard K 563) running on the same kind of ore

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Western Tennessee—Stewart county—Saline furnace (K564) has exhausted her ore banks and stopped, Christmas 1854.—Great Western furnace (K 565) has its brown hematite banks near by, on the dividing ridge between the rivers.—Iron Mountain furnace (K 566) uses brown hematite, both pipe and pot ore, scattered over the surface of the ground in the neighborhood. No permanent bank has as yet been

[3] Joseph Lesley, Jun., in Bulletin Amer. I. Ass., 1858.

discovered.—Peytona furnace (K 567) between the rivers, has rich banks within a mile both north and south of it.—Clark furnace (K 568) on Leatherwood creek, has ore within 300 yards north of west. Out since December 1856.—Lagrange furnace (K 569) on the same creek a mile from Tennessee river, has banks one and a half miles down the river.—Eclipse furnace (K 570) on Hurricane creek, four miles north of the river, has banks two miles to the west.—Cross creek furnace (K 571) has ore in the immediate vicinity.—Rough and Ready furnace (K 572) has not run since 1856.—Bellwood, Bearspring and Dover No. 2 are three furnaces clustered between the Cumberland rolling mill and the forge, on the Cumberland river, and with mines in the spurs around them. The Bellwood is on the east side of the river. The ore used (brown hematite) is the same as that which supplies Dover No. 2, and is got from the "Bear spring ore bank," situated about three-quarters of a mile due west from the mouths of North and South Cross creeks. This bank, which has been mined since 1829, occurs at the end of one of the fingers of the long dividing ridge between Cross creek waters and Bear spring hollow. Along this ridge, but principally in its fingers, many banks, affording a very superior quality of iron ore, have been opened and are now worked. At one of these banks, some two miles northwest of Dover No. 2 and five miles west from Cumberland iron-works, appears a solid bluff of very rich ore intimately mixed with fine flint rock to such an extent that the ore cannot be used for fear of chilling up the furnace. From these banks small cars drawn by mules convey the ores without transhipment over a cast iron railway of cheap and simple construction to the river bank, where they are let down by a windlass over an inclined plane on to a long boat which is employed to float them to the north bank. There they are taken up by a similar plane to a railway half a mile long leading to the furnace. The Bear spring furnace ore bank is close to it and still very rich.—Ashland furnace (K 576) has a bank of very rich brown hematite, mostly pot and pipe ore, within half a mile, but very hard to get; some of it occurs in thin slabs, which, when struck, ring like bell-metal.—Union furnace (K 577) stopped in the fall of 1854, having only blown six months, for want of ore in the neighborhood in sufficient abundance.

Montgomery county; Poplar spring furnace (K 579) has superior brown hematite ore lying around the works, the heaviest deposits occurring half a mile south and one and a half west.—Yellow creek furnace (K 580) uses a superior pipe ore worked by drifts under a hundred feet of cover.—Sailor's Rest furnace (K 581) uses pipe ore from banks one mile from the river and the mouth of Yellow creek.—Montgomery furnace (K 582) has pipe and block ore in three banks, the best half a mile north of Palmyra, and the other two less than a mile and a half north-northeast and due south.—Antonio furnace (K 584) on East Yellow creek, uses brown hematite (honeycomb, pot and pipe) from four banks, 280 yards due east, 180 yards southeast, 430 yards due north, and a short distance due west, the whole lying along three lines of hills which inclose the furnace. At one of these banks, over limestone, are seen blocks, lumps and pots of ore, isolated or in masses 4 to 5 feet thick, scattered through the clay and chert; this ore yields 40 per cent raw, or 55 to 58 per cent roasted. It is exposed by stripping, and worked by Irish and German laborers, who raise four loads ($1\frac{1}{2}$ ton per load) per day for \$1 per load. Furnace burnt down and rebuilt 1857, and December 25 of same year Mr. Vanleer retired from the firm. (Correspondence). Blew in March 29, 1858.—Louisa furnace (K 585) uses a bank 600 yards west of it in a north and south range of hills, the

ore being found from the surface down to a depth of sixty feet.—The other four furnaces of the county are abandoned.

Dickson county; Cumberland furnace (K 590) on the iron fork of Barton creek uses pot and honeycomb ore from two ridges, the banks being one and one and a half miles distant.—Carroll furnace, on another branch, has its ore nearly three miles west on still another branch of Barton creek.—Bellevue, the old Mammoth furnace (K 592), had plenty of good ore, but it is nine miles off, and the river is 18 miles away, so it fell to ruin.—Worley furnace (K 593) has abundant pot ore, rich, worked in banks, 300 yards distant, and on a level with the tunnel head. Two mules haul all the ore necessary to run this furnace.—Piney furnace (K 594) has good ore three miles off, but hard to get.—Laurel furnace (K 595) has ore hard to get half a mile distant, and also nine miles distant, which is too far to haul, so the furnace was abandoned and turned into a camp-ground, the pulpit being placed appropriately in the run out arch.—Jackson furnace (K 596) has its banks seven miles off to the south-southwest, and will probably never run again.

Hickman county; Oakland furnace (K 597) has brown hematite ore banks a mile and a mile and a quarter south.—Ætna furnace used honeycomb ore principally, but has not been in blast since 1855.

Perry county; Cedar grove furnaces, close together and alternately in blast, run upon lump ore from the neighborhood.

Decatur county; Brownsport furnace (K 601) and Decatur furnace (K 602) run upon the same kind of ore as the rest; the latter has banks from one to one and a half miles east of it.

Hardin county has but one furnace, Marion, on the right bank of the Tennessee river.

Wayne county; Forty-eight furnaces, close together, and lately pulled down to rebuild as one large stack, ran on pot ore, found good and in large quantities 200 yards east.[4]

The range of values to be assigned to the brown hematite ores just described, as well as to the brown hematite outcrop ores of the eastern and western coal-measure carbonates can be seen by the following table of percentage of peroxide of iron in various specimens sent in to the office of the State Geologist at Frankfort, Kentucky; and by consulting the pages of analyses in the Reports of Dr. Owen and his assistants; showing moreover the intimate and constant admixture of silica, alumina, lime, magnesia, manganese, zinc, sulphur, phosphorus and carbon in these curious and important beds, more about which will be said in Chapter IV to follow. The absence of protoxide of iron in these specimens makes the proportion of peroxide to iron *constant*. The general absence of protoxide in the western ores is the only doubt cast upon their proto-carbonate origin.

[4] Bulletin American Iron Association, notes, 1858.

Dr. Peter's Analyses of Kentucky Limonites.

Spec.	Perox.		IRON.	Spec.	Perox.		IRON.
655	91.78	=	64.27	59	63.20	=	44.26
436	88.51	=	61.98	94	62.90	=	44 04
36	87.00	=	60.09	654	62 25	=	43.59
425	85.91	=	60.16	146	62.20	=	43.20
117	85.16	=	59.63	419	62.12	=	43.50
428	84.45	=	59.14	489	62 01	=	43.46
442	83.83	=	58.70	318	61.00	=	42.78
144	83.80	=	58 68	414	60.90	=	42.65
95	81.87	=	57.33	147	60 70	=	42.50
292	81.40	=	57.00	57	60.50	=	42.35
83	80.60	=	56.44	413	60 18	=	42.14
448	80.50	=	56.37	33	60 00	=	42 00
307	80.30	=	56.23	46	58.90	=	41.24
437	80.20	=	56.14	130	58.75	=	41.14
290	80.03	=	56.02	478	58 30	=	40.82
5	79.90	=	55.95	453	58.30	=	40.82
421	79.40	=	55.60	103	57 90	=	40.53
473	78.43	=	54.93	96	57.10	=	40.03
293	77.50	=	54.25	105	56 70	=	39 70
418	76.90	=	53.85	93	56.50	=	39.56
316	76.90	=	53.85	747	56.14	=	39.31
81	76.20	=	53.36	420	56.10	=	39.28
415	74.70	=	52.31	35	54.60	=	38 23
431	74.50	=	52.17	653	54.08	=	37.87
412	74.30	=	52.03	399	53 46	=	37.44
291	73.90	=	51.75	444	53 44	=	49.39
439	73.34	=	51.36	131	52.16	=	36.52
476	72.80	=	50.98	441	51.10	=	35.78
34	72.70	=	50.90	72	51.00	=	35.71
82	71.90	=	50.35	438	49.90	=	35.06
142	71.74	=	50.24	32	49.69	=	34.79
12	71.50	=	50.07	54	49.45	=	34.63
143	71.50	=	50.07	147	48.70	=	34.10
58	70.30	=	49.23	31	41.70	=	29 20
429	69.60	=	48.74	309	41.40	=	29.00
474	68.30	=	47.83	119	39.90	=	28 48
317	68.20	=	47.76	23	39.60	=	27.73
45	68.10	=	47.69	405	39.48	=	27.64
70	68.10	=	47.69	727	39.34	=	27.55
73	67 50	=	47.27	69	38.50	=	26.96
13	67.40	=	47.20	139	35.97	=	25 27
417	67.14	=	47.02	635	34.60	=	24.23
55	66.90	=	46.85	589	33.99	=	23.80
446	66.76	=	46.75	107	32.10	=	22.48
442	66.03	=	46.24	546	27.18	=	19.00
80	65.30	=	47.82	609	26.69	=	18.69
106	64.70	=	45.31	71	26.60	=	18.62
44	64.18	=	45.00	289	24.70	=	17.29
424	63.60	=	44.54	450	23.70	=	16 59
408	63.60	=	44.54	11	23.20	=	19.24
451	63.60	=	44.54	634	20.87	=	14.61
56	63.50	=	44.54	104	13.25	=	9.27

The later brown hematite ores, both those of the Tertiary and those of the Quaternary and existing ages, are of so different a character from the foregoing in the practical working and history of the manufacture that they fall systematically under the head of **Bog ores** and are discussed in the fifth chapter.

FOSSIL.

CHAPTER III.

THE DYESTONE FOSSIL ORE.

The Fossil Ore has been studied in Clintor county New York, at Danville and Bloomsburg on the north branch Susquehanna in Pennsylvania, at Hollidaysburg at the head of the Juniata in the same State, along the foot of the Cumberland mountain in Eastern Tennessee, and at Maysville in Wisconsin. We will take them in this order, in describing the localities. These are the regions wherein this extraordinary deposit has been best developed, so far as its outcrop-lines present opportunities to study it. No doubt beneath the superincumbent masses of later formations in many places other local instances of greater size exist which never will be reached by the miner's pick or known to the geologist. Such an outspread of one, two or three thin strata of red hematite, inclosing grains of limestone, sand or shells, fragments of coral and perhaps sea-weed, almost coextensive with the United States, not long preceding in the order of time the appearance of the Oriskany seacoast, while it argues a deep extensive ocean, wide gentle currents, and a chemical action quite universal, involves of course such variations in the process of precipitation as insure the local character of the ore beds in a workable or valuable form. When the whole edge of the formation is upturned and cut down to the level of the country it is consequently found to vary greatly, sometimes being two feet thick, or very pure, and at other times but a few inches thick, or equally impure. When we speculate upon the origin of the ferruginous matter, we are left to conjecture extensive rivers, bringing into and spreading over the bed of the ocean ferruginous mud from a country of Lower Silurian and Primary rocks, occupying what now are the British possessions, Canada and the Adirondac regions of New York,—rocks themselves loaded, as we have seen, with iron ores of every variety, specular, magnetic and brown hematite. Perhaps the very strata of the Lower Silurian, the present edges of which now

yield the brown hematites of the Great Valley, had then an early and now no longer existing range of brown hematites deposits upon their more ancient outcrops. If it be asked why this influx was not constant,—why it did not occur through the long Hudson river period (III), through the Shawangunk and Medina period (IV),—why it waited for the present epoch and recurred at intervals three or four times,—we are at a loss to answer, except that, perhaps, only now and only during these short recurrences, the Lower Silurian and Primary region lay above the surface, and moreover, after the troublous times which succeeded the deposition of the Hudson river slates now first returned the quietness in which the iron and lime could be precipitated. It is observable that during the previous age (No. IV) sand was the chief deposit, white first, then red, with pebbles, and seaweed, showing a new shore; and on this new shore the lowest or sandy ore was evidently thrown; and so locally that we may see it, in imagination, being distributed around the mouths of streams. Afterwards, when the ocean bed was better equalized, the waters quieter, the mechanical deposit muddier, and the molluscous and coralline life more secure and abundant (towards the east, for towards the west, as in Wisconsin, the sea was too deep to bear life and no fossils are there seen in the ore bed), then the still wider mingled lime and iron precipitation took place, no doubt under the influence of that occult law by which decomposing organic form has always determined the chemical mineral changes. Rogers supposes the sudden appearance of the iron as a precipitate may be due to the new and sudden influx of carbonate of lime into the ocean. This however would implicate extraordinary mutations of the continents whence came the rivers feeding the ocean in question. He says:

These regularly-bedded ores of the Surgent series are to be regarded as among the permanent constituent strata of the formation, and as having originated, with the other sedimentary materials, in the form of very extended but thin sheets of ferruginous matter, covering at successive epochs the wide floor of the quiet Appalachian sea. Whence all the oxide of iron was derived which mingled with the earthly deposits of clay, sand, carbonate of lime, and the fossils of these deposits, is a question which the present state of research scarcely enables us to answer. Perhaps we are authorized, from a consideration of the physical changes which seem to have occurred at the close of the Matinal period, to refer its origin to a wide expanse of newly-upraised land of Primal and Matinal sediments, impregnated with a certain proportion of furruginous matter, and to suppose that these parts, freshly exposed

New York.

to active erosion and waste by atmospheric agents, in supplying a part at least of the materials of the Surgent strata, contributed, by steady accumulation, a copious amount of the salts of iron in solution to the waters of the Levant ocean. We have only to imagine, in the next place, the operation of certain well-known chemical reactions, such especially as would arise upon the sudden introduction of calcareous matter, to perceive a sufficient cause for the extensive precipitation of a definite quantity of the iron in the form of the peroxide. This explanation derives some countenance from the independent evidence afforded,—by the more calcareous and fossiliferous nature of these ore beds, compared with the strata which embrace them,—that the epochs of the deposition of the iron ore were also the periods of the most copious supply of carbonate of lime. To this source we may ascribe, with some probability perhaps, a large portion of the peroxide of iron in these layers; but we must not overlook another train of causes, operating since the elevation of the strata, to contribute in certain situations an increased supply of this ingredient. An enormous quantity of ferruginous matter, both in the shape of sulphuret and peroxide of iron, is diffused throughout the substance of the slates, shales, and marls in contact with these layers of ore; and the infiltering waters have probably conveyed some of this, chiefly in the condition of sulphate of iron, into the ore bed, where the carbonate of lime of the fossils would convert it into the peroxide. That such has been the origin of part of the iron in the "fossiliferous ore" of some localities, is indicated by the general richness of the ore in peroxide, in all situations where the position of the outcrop, the slope of the ground, and the thickness of the covering slate, are favorable to a copious infiltration of the surface water.[1]

In New York the belts of Upper Silurian formations sweep along the hills south of the Mohawk valley westward past Syracuse, Rochester and Niagara towards Detroit. The fossil ore of V (the Clinton group) appears among them as a thin knife-edge in Montgomery county and thins away again to a knife-edge in Monroe county. In Hall's district of Western New York it is sometimes a valuable ore bed supporting furnaces; but its outcrop is fluctuating and uncertain, coming and going in a capricious manner, sometimes leaving in its place a mere tinge of iron red in the upper part of the Lower Clinton Green Shale on which it rests, or on the Lower stratum of the Clinton Pentamerus limestone on it. The quantity of original iron was of course limited and its diffusion coextensive with the Palæozoic continent, so that nothing could be more uncertain than the local thickness of its sediment. But as, perhaps, it was not originally cast down pure, but subsequently filtered from the ferruginous lime- and sand-muds of the Upper Silurian Waters, so in its descent to form a permanent bed, it seems to have been ar-

[1] Rogers's Final Report, vol. ii. p. 727.

rested sometimes, by the Upper Clinton Green Shale before it could reach the Lower.

Vanuxem reports the iron ore beds, two in number, to range with very little interruption throughout his district. No indication of the existence of the Clinton group as a whole is seen east of Squak (Otsquak) creek, at Vanhornsville, where at the foot of the dam, blocks containing iron ore and *agnostis latus* are numerous, over green shale containing (*Hemicrypterus Clintoni*) a trilobite [2] At Crugar's Mill, in the town of Warren, the ore was once tried, and made good iron. South of Mohawk village in the branches of Steele's creek, the upper bed of ore may be seen in place and its fragments in the creek show the encrinal joints weathered out (having been replaced by lamellar yellow carbonate of iron) and fragments of *Hemicrypterus Clintoni*, particularly the tail, with *agnostis latus*. South of Utica Wadsworth's ore beds are opened between the upper and lower sandstone quarries. The fossils of the sandstone or blackstone at Davis' quarries, including the *palæophycus bilobatus* (a sea-weed found by Vanuxem in the same rock where it rises again in Pennsylvania at Bloomsburg and in Ohio) and *agnostis latus*, are changed into brown hematite, "as if they had originally been sulphuret or carbonate of iron," says Vanuxem ; but in fact the carbonic acid of the waters holding in solution the protoxide of iron would deposit it in the moulds of the fossils while the same acid waters were dissolving their carbonate of lime away. The ore pits between the quarries show a red or brownish red "lenticular clay iron ore," as Dr. Beck calls it, very hard when unaltered, invariably oölitic (fish-roe-like), or in larger size concretions. The two beds average a foot or so in thickness and 20 feet apart, the larger concretions most affecting the upper and the oölitic structure the lower bed, in which also occur sometimes brownish shales in lens-shaped pieces, and bluish black grains of oxide of manganese. Whole fossils or fragments are common in the upper but not in the under bed. In the Fourth District (Mr. Hall's), the calcareous shales containing the *pentamerus oblongus* shell comes in between the two beds of ore. The Wadsworth ore bed is the lower one, highly oölitic, with brown shale and *agnostis latus*, and lies almost perfectly flat, as all these formations in New York do.

On Swift creek, a branch of Sauquoit creek, at Rodger's machine factory (1841), a complete section of the same sandstone, full of the sea-weed, of 35 to 40 feet of shale above it, with *agnostis latus*—of 14 inches of hard greenish grey sandstone over the slate—lastly, of a foot of highly oölitic, non-fossiliferous, pure red ore—over which lie 20 feet of greenish blue shale, with thin layers of colored sandstone with sea-weed, and then the second or upper ore bed, two feet thick, less pure, because somewhat calcareous, oölitic and encrinal (or full of stems of stone lilies). In fact the mass for a few feet above and below the ore is a mixture of limestone, shale and fossils, among which is the flat, radiated shell *strophomena Clintonii*, and the English shell *strophomena depressa*, seen here for the first time going west. Above this upper bed lie thirty feet or more of greenish blue shale and slate with darker sandstones, etc.[3]

Near New Hartford, at Reed's saw-mill, the two ore beds are twenty feet apart, and of the same relative sizes and qualities as before, and the upper bed with peculiarly well-preserved shells. On the road hence to Clinton are numerous diggings

[2] The *trimerus delphinocephalus* came into existence with this ore bed and existed through the Niagara group.—VANUXEM.

[3] See Vanuxem's description Report, 1842, p. 85.

in the alluvion over the flat lower bed which is here leached pure and runs two and a half feet thick. **New York.**

In Stebbins' creek, the upper bed appears on each side of the bridge, oölitic and also full of masses, once corals, stone lilies etc. now coated with iron or wholly replaced by it. Curiously enough the corals are all changed into the peroxide and the encrinites into the carbonate of iron. The lime in the rock continues to increase through the town of Clinton, and the ore mass is four feet thick over seventeen feet of sandstone, shale etc. and then comes the lower but poorer ore bed, under which are five feet of sandstone and shale, and then a third or lowest iron ore bed, hard and sandy, ten inches thick, under which are green shales and thin flagstones. It will be seen hereafter that the ore formation in Pennsylvania is also triple.

At Ruddock's quarry, southeast of Clinton village, the upper bed is seen at the bottom mixed with yellowish limestone, without its usual concentration. The same is the case at Griffin's quarry, towards the north of Hamilton College hill, where the upper layer of iron-charged encrinal limestone is five feet thick, overlying strata of limestone-shale "as if kneaded together," thin limestone with some shale and more iron than the uppermost mass, oōlitic, coppery-bright, with encrinal discs coated with oxide of iron. The whole belongs to the upper ore bed. Dr. Hopkins's quarry, nearer the college, the encrinal limestones and sandstones with iron ore alternate several times, all belonging to the upper ore bed. At Dr. Norton's quarry near by, is the lower ore bed, oölitic, and formerly worked to smelt.

Between Utica and Vernon, near the Kirkland town line, at Bennet's Bank, the lower ore bed is on top of the hill, with green shale, and shows inside brown shale and grains of manganese. A great thickness of sandstone below the bed may here be studied. Between Manchester and Lairdsville, the Bennet ore appears again, with *agnostis latus.* Opposite Lairdsville on the north, in the ravine, is the upper ore bed (under ten feet of shaly sandstone), two feet thick, and much mixed with rock, over four feet of fossiliferous sandstone and shale, over twenty feet of alternating shales and thin sandstones and limestones, showing iron ore, under which comes the lower bed two feet thick, oölitic, fossiliferous as at Bennet's and Norton's.

Next to Westmoreland furnace, the ore is exposed in many places, particularly the lower bed, and when long exposed, pyrites decomposed and the rock softened, is very good.

Hence through the west part of Kirkland, Westmoreland and Verona, the measures flatten out and show purer outcrops. Near Verona the flat ore covers a large surface, and in 1841 was quarried for the Taberg Company on Eames' land, under eight feet of drift, for the Lenox and Constantia furnaces on Person's land; solid ore, twelve to fourteen inches thick. It was struck in a well in Verona. The Eames ore underlies a few feet of hard sandstone, full of a coralline fossil, *retepora Clintonii*, the same that exists next the ore.

At Wolcott furnace, and in the Martville blue green calc shales, which there represent the upper ore bed. South of Verona the loose ore of the upper is sometimes seen, with geodes in the blocks and a peach-bloom like the arseniate of cobalt, and fragments of *pentamerus oblongus* and *atrypa affinis* (the lowest appearance of an atrypa known).

From Verona to Madison county the country is flat and marshy and Lake Oneida is excavated in the Clinton group. In Madison county therefore the first locality of the ore is on the Lakehead-Conastota road at Donelly's, where masses of the lower ore bed are ploughed out, an island-like patch of the red rock, a hundred acres in extent, surrounded by swamp land. The ore mined here is calcareous, needing a

sand-clay flux to smelt it, and extraordinarily full of fossils, pentamerus oblongus, atrypa affinis strophomena depressa, delthyris radiatis.

In Joselin's corners the ore appears between the road and the lake, 2 feet thick, in two layers of several hundred feet horizontal outcrop, smelted formerly at Constantia furnace and not much liked. Further west on the lake shore at R. Bushnell's, several small seams appear in the sandstone. It crosses the Seneca river at the rifts between Granby and the outlet; exists probably on the road to Hannibalville at Bentley's quarry; and on little Sodus creek between Martville and the mill. The last place in Vanuxem's district where he saw the ore is west of Sterlingtown in Van Patten's fields.[4]

Its greatest thickness in Wayne county, 2 feet, is at Ontario town. Between this and the Genesee river, twenty miles, its outcrop covered by a thin spread of drift, is seldom seen. On the Genesee it is about 14 inches thick, and further west it was nowhere seen by Hall except as a discoloration of the ferruginous rock above. It is absent in the Medina, Albion, Lockport, and other good sections. Hall suggests that this thinning west may be indicative of an eastern origin, hinting at the beds of specular and micaceous ores of northern New York. But its more probable origin he thinks may be decomposition of sulphuret of iron; while as Vanuxem's facts go to show, the oölitic form may be due to thermal waters. It is remarkable that the upper second bed of ore, which occurs at a few places, but never of a workable size, never occurs at the places where the lower bed exists in force. This is not true of the Pennsylvania deposits as will be stated hereafter.

The Walcott ore bed, six miles east of the furnace, is as Hall thinks the upper bed, and is here much thicker than elsewhere. At the furnace itself the upper bed is but a few inches thick, associated with impure limestones, and the lower bed is absent. The openings between this and Sodus point seem to be all of them in the upper bed. At the Shaker village at Sodus point large fragments of ore were found belonging to the upper bed for the place of the lower bed is seen and vacant. West of this the upper bed is not seen. The ore got north of Sodus point and in Ontario town is evidently from the lower bed.

In **Pennsylvania** the ore reappears from beneath the great area of Devonian and Carboniferous rocks (VIII XIII), round the eastern or Catskill mountain end of which, along the Hudson valley and Newburgh-Stroudsburg-Orwigsburg valley, it does not show itself in any thickness, and often not at all. Blocks of the lower red sandy ore were picked up by the author in 1839 at many places along the northern slope of the Blue or Kittatinny mountain, especially upon the anticlinals of the Little Schuylkill; but no fossil ore has ever been found upon this its most southern outcrop between Newburgh on the Hudson to the Susquehanna Gap above Harrisburgh. Nor after crossing the Susquehanna does it assume importance until far into middle Pennsylvania, as will appear directly.

[4] Report of 1842, p. 90.

Pennsylvania.

At Danville and Bloomsburg, on the broad back of Montour's ridge, which lifts a double line of it to the surface, further to the north; and at Milton, Wilksbarre, Altoona, Frankstown and Cumberland, on the north flank of the Bald Eagle its next great line of outcrop, the case is different.

At the Narrows two miles below Danville the ore sandstone is seen 8 feet thick, calcareous, separating the upper and lower shales; in the lower shales are the ore beds, too thin to work, for which Chulasky furnace was built. Westward of this the ores are not workable. Towards Danville the sandstone ore breasts up above water level 200 yards, the fossil ore much less. East of Danville there is not much difference between the sandstone ore and an ore in the lowest slates of the series; each is a sandstone infused with peroxide of iron, and including numerous small flat fragments of greenish slate, weathering out and having in cross fracture little lens-shaped holes, a characteristic mark of these ore beds in many places. This lowest ore bed of all is only 6 or 8 inches thick, except at Wood's mine on the north slope four miles east of Danville where the principal layer is from 18 to 30 inches thick, but not all equally rich; at the Bittenbender mine 1½ mile further east it is again but 8 inches, and rich, mixing well with the soft and hard ores above it in the series. At 4 miles of outcrop and 50 yards breasting there will be of this ore 350,000 tons. The iron sandstone girdles the mountain with its outcrop, but nowhere yields its central ore in a workable shape; the deposit is too poor. At Hemlock creek it spans the end of the mountain in a fine high arch, but its ore is poor.

Professor Rogers gives the following section of the Upper Silurian (Clinton, Surgent) No. V red shales in which the beds of ore occur:

Red shale, with a few green, no fossils	380 feet.
Red and green shales alternately	60 feet.
Upper calcareous shales, sandy, fissile, often highly fossiliferous, with fossil limestones 1 to 12 inches thick. Fossils: *Beyrichia*, *Atrypa*, *Avicula*, *Strophomenæ*, *Euomphalus*, *Encrini*, *Favosites*, etc.	160 feet.
Ore Sandstone, calcareous, tough, with thin shales	8 feet.
Lower calcareous shales, green, fissile, with thin limestone plates and eight or nine thicker, all fossiliferous, and with the **Fossil Ore** band 1..4 thick 25 feet from the bottom	60 feet.
Upper Slate, green, *fissile* with thin clay sandstones, and the only fossil is *Buthotrephis gracilis*	50 feet.
Iron Sandstone, with its **Hard Ore**, 1..4 thick	58 feet.
Lower Slate, green, weathering yellow, sandy, *compact* or fissile, with its **Ore band** about half way down its thickness, and the Clinton fossil *Buthotrephis gracilis* throughout it	700 feet.

These *Lower Slates* are distinguished from the upper by being more compact. In their midst are one or two layers of sandstone ferruginous enough sometimes to mine. These are the lowest and hardest ores, 300 or 400 feet above the great white

sandstone Formation IV which forms the core of the mountain and the ribs and crests of most of the mountains of middle Pennsylvania. The *Iron Sandstone* next above is a triple formation of ponderous layers of red argillaceous and ferruginous sand rocks inclosing a middle member of green sandy slate, the sandstones thickening eastward. The lower member sometimes two or three layers of workable iron ore, and the whole formation marks its outcrop on the surface by a ragged ridge. The Upper Slates increase in thickness eastward. These form the lower or slate divisions of For. V. The next or middle division was formerly called the marly layers of V.

The Lower Calcareous Shales graduate into the Slates below them so that the partition lines are not very exact, but are too well marked as a formation by numerous thin grey limestone layers and fossils to be overlooked. These contain the famous **Fossil Ore Bands,** variable in number, thickness, and distance asunder, because consisting really of nothing more than some of the limestone layers more highly charged with peroxide of iron than the rest. The principal layer varies from 14 to 20 inches thick along the Southern or Susquehanna slope of the mountain, where it has been chiefly mined, and at its eastern end, where the axis sinks and carries the formation slowly down with it beneath the Berwick and Wapwallopen country to the east.—The Ore Sandstone, with its encrini, is here a thinner rock than in Middle Pennsylvania, and not so good a landmark therefore for the ore.—**The Upper Calcareous Shales** have also their thin beds of fossil limestone (some of which, near Danville, are massive enough to quarry, but too clayey and magnesian for a flux) but no ore, although the lower layers are ferruginous and become good ore beds in Middle Pennsylvania.[5]

The marly shales form the upper or third division of the formation, their lower (surgent) layers being red and green and red 380 feet, the middle (scalent) layers variegated, the upper (scalent) layers grey, 1,300 feet, with massive limestones 20 or 30 feet thick, and introducing us to the Limestones of Formation VI (Scalent and Premeridian of Rogers, Lower Helderburg of New York.)

The ridge at Hemlock creek is a double anticlinal or an anticlinal fallen in a little at the summit. The ore rises on each

[5] Final Report, i. 435 +.

flank, and is mined at the gaps. The outcrop of the limestone ore beds, for some distance in, is weathered to a soft red porous mass like bog ore full of more or less distinct small fossils. The limestone ore within is hard, tough, breaking along the planes of innumerable small shells and rings (the joints of encrinal foot-stalks or stone lilies) glittering with an enamel of black or reddish-black oxide of iron, and the pearly white scale-like separated films of shells, mixed with specks and fossil forms of the red oxide where at innumerable points the attack of the air and water had begun. The fossils are all in a perfect condition, except that the encrinal columns have fallen to pieces, and this fact would go to show, when taken in connection with the immense extent of the deposit and the absence of coralline masses, that the ocean in which the iron was disseminated and precipitated was comparatively deep. Yet the shore could not have been very far off to the southeast, for the ore is not found along the Blue mountain from the Delaware Water Gap to the Susquehanna. And Formation VII was in great part a beach formation, containing at Cumberland in Maryland, and in Lewis county in Southern Virginia, masses of fossils rolled upon a beach, as Hall will show. Some wide, slow oceanic current from an unknown quarter, charged the American Upper Silurian Ocean with a fine ferruginous calcareous sandy mud, which settled in mass, and then adjusted its constituent elements in layers according to their insolubility, the carbonate of lime by itself first, and the fine ferruginous sandmud by itself next, from which the iron separated itself afterwards and fell upon the limestone beds to convert them into ore; the fossils acting as determining horizons for the segregation of the limestone first and the iron afterwards.

The amount of this ore Mr. Rogers calculates at 4 miles outcrop, 200 yards breast 15 inches thick, giving 1,400,000 tons above water level. For the fossiliferous ore Mr. Rogers calculates a workable outcrop of eight miles on each side of the ridge, an average depth of 30 yards for the soft ore, equal to 210,000 tons, and admitting the hard limestone body of the bed to be workable another 30 yards down, the whole amount is not over 400,000 tons. The whole possible amount of workable ores of V in Montour's ridge above water level will then be somewhat over 3,500,000, the soft ore making about one-third, which is about the proportion of its use in the furnaces. He adds that twenty furnaces [6] were running on the

[6] In 1857 fourteen anthracite furnaces ran on this ore *wholly* (A 95, 96, 101 to 112), and eleven anthracite furnaces mixed it with magnetic alone (97 to 100, 113), or brown

ore at the rate of say 180,000 tons of soft ore per annum, which would exhaust the region above water level in twenty years. This, a note says, was written in 1847, and he goes on to advise the careful husbanding of the soft ore as the principal wealth and sine quâ non or "present key to the remaining riches of the region." [7]

Mr. Rogers adds, on page 729 of his second volume: But I must here advert to another much more instrumental cause of inequality in the proportion of iron, compared with the other constituents—I mean the *removal*, by infiltrating water, of a part or all of the soluble portion of the ore, chiefly its carbonate of lime, both diffused and in the shape of innumerable organic remains. The fossils, chiefly shells and joints of the Crinoidea, constitute in many instances fully one-half of the weight of the ore in its original unaltered condition, as the reader can ascertain by inspecting the Table of Analysis of the Surgent Fossiliferous ores, and comparing the amount of carbonate of lime of the compact specimens with that of the soft or porous ones. It is obvious that a given bulk of the ore must retain, after the abstraction of this large quantity of calcareous matter, very nearly twice its former percentage by weight of its principal ingredient, the peroxide of iron. A study of the circumstances which chiefly influence or control this dissolution of the carbonate of lime is therefore of the highest practical importance, since only through a competent knowledge and application of these conditions to his particular localities can the proprietor of a tract of this ore foresee the relative amount of the soft or chiefly valuable variety which his ground is likely to contain. The whole value of the Surgent ore beds, so far as the quality of the fossiliferous ore is concerned, depends upon the depth *below its outcrop* to which the dissolving process has extended; for experience has now confirmed the views which I ventured to express in my annual reports, that the stratum cannot be profitably mined, in the present condition of the iron manufacture, much below the level to which this surface action has penetrated.

What, then, are the conditions of outcrop that principally promote the thorough and extensive filtration of the waters along the slope of the ore stratum? The most favorable state of things is a coincidence in the dip of the ore bed with the inclination of the ground above it. In this case, nearly the whole of the rain which falls upon the hill-side finally penetrates to the layer of ore, and passing through the thin covering of slates, carries with it an additional amount of oxide of iron. A strict parallelism between the ore bed and the surface seldom prevails over any considerable tract, almost never on the side of an anticlinal or monoclinal ridge, and scarcely anywhere but at the end of a broad anticlinal ridge like that which terminates Montour's ridge east of Bloomsburg, where there is a truly extraordinary quantity of the softest and richest ore arching the point of the hill in a gentle curve, and nowhere overlaid by a thicker covering than from 10 to 20 feet of the slate. Where the dip of the ore is considerably steeper than the slope of the surface, the thickness of the overlying rocks rapidly increases as the bed descends, until its mass becomes too great to be penetrable by the atmospheric waters. In all such cases the ore, as we trace it downwards, grows progressively less soft, porous, and rich in iron, more and more of the substance of the fossils remaining undissolved, until we reach a point at which the stratum is in its original con-

hematite alone (92, 93, 114, 115), or with both (91, 94), but three of the number obtained theirs from another region. A charcoal furnace (E 81) in Maryland, and five others (E 104 to 108) in the neighborhood used it. See Bulletin tables.

[7] Final Report, pp. 443 to 450.

dition, with its maximum quantity of the carbonate of lime, and therefore its minimum of peroxide of iron. It should be observed that this limit is by no means as far beneath the outcrop, even under the moderate dip of 30°, with the surface sloping 15°, as many persons imagine. Much observation along the ore belts of Montour's ridge and other districts, persuades me that, under these conditions, the soft ore ceases, on the average, at a distance of 30 or 40 yards from its actual outcrop. Where the bed of fossiliferous ore dips *into* the hill, or in a direction contrary to the slope of the ground, the surface-water flows across its outcrop without entering it, and the stratum in this case receives a very small supply of infiltering water, so that not unfrequently the ore is compact, and full of its organic remains, to within a few feet of the soil.

To those interested in the many iron furnaces now erected, which depend, in part at least, for their supply, and mainly for the quality of their iron, upon this admirable variety of ore, the following calculations, based upon the foregoing data, will not be without their value. Assuming the average thickness of the main bed of the fossiliferous ore to be 16 or 18 inches, each square yard of the stratum will contain about one ton ; and if the average width of the breast of soft ore be taken at 35 yards, then one mile of continuous outcrop must furnish the amount of 61,600 tons. It should be borne in mind, however, that several circumstances, besides the mere relative slope of the ore and of the surface, may influence the amount of percolation, and produce locally wide deviations from the above estimated width of the soft outcrop ore. Such are especially any irregularities in the contour of the ground, in the form of ravines, or knolls and swells ; and again, any local contortions or dislocations in the strata. In regard to the silicious ore beds of the Surgent series, both those of the iron sandstone and the Surgent older slate, the quality of the ore is very uniform, being but little influenced by the accident of proximity to the surface. Possessing but few fossils, and only a comparatively small proportion of calcareous matter, these ores are not susceptible of the purifying process so essential to the so-called "fossiliferous ores;" and hence, so far as their richness in iron is in question, it is of small importance what way the strata dip in relation to the slope of the surface. The direction of the dip will much affect, however, the extent to which the outcrop of the bed may be uncovered, but can thus influence only to a trivial extent the facility and cheapness with which it may be mined. When the "hard ore" is of equal or nearly equal thickness with the "fossiliferous ore," and contains as much as 30 per cent of iron, it is obvious that it will long outlast the latter in most of the localities where at present they both abound. Not deteriorating materially as it descends, and outcropping higher upon the flanks of the ridges, in consequence of its holding a lower place in the series, the supply of this variety of ore may be regarded as liable to few fluctuations, and to be almost inexhaustible. The average cost of mining the soft fossiliferous ore, at and near its outcrop, exceeds \$2 per ton, while that of removing the "block ore" of the iron sandstone is from \$1 25 to \$1 75 per ton.

Mr. Rogers has added the analyses of these ores of V, made during the progress of the survey, to the essay quoted above, in the form of the following table :

TABLE OF ANALYSES OF

Locality and Variety.	Peroxide of iron.	Oxide of Manganese.	Alumina.	Silica and Insol. Matter.
1. Smith's Gap, Kittatinny Mt., Dauphin Co..	68.00	....	6 60	13.30
2. Danville, Columbia County (Levant iron sandstone)........................	70.63	....	.57	23.77
6. Danville (calcareous fossiliferous ore).....	30.34	a trace	....	2.64
7. Bloomsburg (compact calcareous, fossiliferous ore)..........................	61.30	....	a trace	2.80
8. Bloomsburg (soft, porous, fossiferous ore) .	85.10	....	5 0	7.10
9. Landisburg, Perry Co. (fossiliferous ore)..	76.45	1 50	1.25	14.40
3. Turtle Creek, Union Co. (Levant iron sandstone)..............................	37.64	....	a trace	59.0
10. Mifflin, Juniata Co. (fossiliferous ore).....	70.0	a trace	a trace	24.24
4. Little Cove, Franklin Co. (Levant iron sandstone)...........................	30.38	....	1.20	67.0
11. Little Cove N.W. side, 4½ miles N. of Warren Iron Works (fossiliferous ore)....	83.0	a trace	6.0	5.3
5. Dickey's Mt., N.W. side, half a mile S.W. of Hanover Forge, Bedford Co. (Levant iron sandstone).........................	52.0	a trace	a trace	39.3
12. Matilda Furnace, near Jack's Narrows, Huntingdon Co........................	74.76	a trace	5 06	13.04
13. Matilda Furnace (lower part of the same)..	44.07	a trace	1.39	52.33
14. Lick Hill, Woodcock Valley, Bedford Co. (used at Hopewell Furnace).............	46.50 part Carb. of Iron.	....	4.80	16.30
15. Hopewell Furnace Mine, Bedford Co. (softest kind)..........................	78.05	.68	4.50	13.85
16. Hopewell Furnace Mine (same bed, compact kind)................................	55.2	.5	1.0	8.8
17. Near Barre Forge, Huntingdon Co. (lower part of vein)..........................	43.55 Prot. Carb. Iron, 3.56.	.50	.50	3.0
18. N.E. of Barre Forge (average of the vein).	57.0	.60	1.40	7.50

West of the Susquehanna, the ore of V is now mined and used at Union furnace (A 113). A good ore bed, 12 inches thick, horizontal, on the Buffalo axis, four miles west of New Columbia, was once worked, but the region along the foot of Jack's mountain where the outcrop runs does not open well. Extensive openings half a mile southwest of Miller's saw-mill in brown hematite and other similar banks belong to the zigzag outcrops of Formation VI.[8]

[8] McKinley in Final Report, p. 459.

THE SURGENT ORES.

Water.	Occasional Ingredients.	Loss.	Metallic Iron in 100 Parts.	DESCRIPTION OF THE ORES.
11.70	....	.40	47.06	Dark mottled-brown, coarse-grained, sandy-looking ore, imbedded in brown hematite.
2.57	Carb. of Lime 2.46	...	48.96	Brick-red, somewhat fossiliferous, has the grain and aspect of a red sandstone Called the "hard ore."
1.80	Car. Lime 62.43 Car. Mag. 2.79	...	21.03	Dark purplish-brown, slaty, micaceous, fossiliferous.
2.20	Car. Lime 33.17	.53	43.00	Very similar to the last.
2.10	Carb. Lime, a trace	.40	60.00	Dark, reddish-brown, soft, gives a red powder, is full of pits and casts of fossils
5.70	....	.70	53.51	Dull brown, slaty, micaceous, highly fossiliferous.
3.20	....	.16	26.32	Pink color, compact, coarse, and silicious, resembles the "hard ore" of Danville.
5.40	....	.40	51.10	Chestnut-brown, coarse, slaty, granular, micaceous, and fossiliferous.
1.42	....	...	21.06	Dark red and brown, granular and sandy, looks like a coarse red sandstone; is the "hard ore."
5.1	Lime, 0.5	...	58.1	Reddish-brown, laminated, porous, fossiliferous
9.0	....	...	36.4	Dark brown, coarse, earthy; variety, Levant iron sandstone.
3.82	Lime 1.35, undetermined matter 2.11,	...	51.84	Reddish-brown, powder red, porous, fossiliferous (upper part of fossiliferous ore).
2.62	Lime 0 49	...	30.56	Brown, fracture rectangular, brown oxide of iron, cementing coarse grains of sand (lower part of fossiliferous ore).
1.0	Car. Lime 31.01	.39	27.72	Pale-red, highly fossiliferous; carbonate of lime of fossils visible.
3.0	A trace of Lime	...	54.95	Brown, powder purple-brown, soft and brittle, fossiliferous, has some red micaceous oxide.
2.5	Car. Lime 31.4	.6	38.64	Reddish-grey; powder light brown; micaceous, fossiliferous.
1.50	Car. Lime 46.76	.63	32 2	Reddish-grey, fossiliferous; the fossils not all dissolved out.
2.0	Car.Lime 32.10	...	39.9	

South of Jack's mountain is a wide stretch of hill country in Perry and Juniata counties crossed by great and small waves, which bring up, in innumerable zigzags, the Upper Silurian rocks of V along the feet of the bounding and subdividing mountains of IV. Dr. Henderson examined and described this country with singular precision and the substance of his report on its fossil ore is to be found in Rogers's Final Report, pp. 336–344.

Along the flank and end of Shade mountain northwest of Selins grove in

Union county runs the triple-crested Chestnut ridge, two of the crests formed of the ore sandstone and the third of the lower slates, but shows no ore. The anticlinal *Slenderdale ridge* stretches from four miles northeast of McAllisterstown to the Juniata fourteen miles, with the iron and ore sandstones dipping 20° southeast and 70° northwest, and shows at but one place the pure fossil ore 6 inches thick *under* heavy beds of greyish-brown sandstone, the true ore sandstone; of course this is a local deposit quite different from the universal ferruginous and worthless upper layer. In the *Long Narrows* of Lewistown, a sharp synclinal basin through which the Juniata flows, the ore must be under the river.

The region of Mifflintown has the iron sandstone only a few feet thick, the ore sandstone being 20 to 30 feet thick, some of its layers white, hard and fine grained, the rest brown ferruginous, a few calcareous and fossiliferous. It forms a ridge along the mountain side projecting in long barbs beyond their anticlinal ends. The ore forms the uppermost layer, as in some of the Mifflin county localities. As a calcareous sandstone highly impregnated with iron its value is small over all Juniata and the lower end of Huntingdon counties. Above it are a few beds of fossiliferous limestone alternating with shale. The ore is mined where the river cuts across the Mifflintown hills.

In Pfout's valley the ore is *oölitic*, but with numerous well defined fossils; these disappear as the bed is traced southwestward along the base of Tuscarora mountain into Liberty valley, the ore remaining for a while purely oölitic, and then graduating into the sandy ore of Juniata county. Everywhere it overlies about two feet the *ore sandstone*. At the one locality where the fossiliferous form was found (at the north base of the Kittatinny mountain at the southern limit of the region,) it looked like Catawissa or Danville ore and had the large encrinal rings so common there. **In Pfout's valley** two miles northeast of Middletown, the compact oölitic ore bed 8 or 10 inches thick lies flat and is stripped. From Brant's mine it is traceable to the Juniata, sometimes steeply dipping and is mined half a mile above Millerstown. On the northwest side of **Raccoon valley** the fossiliferous ore ranges along the southeast flank of the ore sandstone ridge, is reddish-brown, compact, oölitic with few or no fossils, thickness small. Northwest of *Ikesburg* the ore sandstone, ore and iron sandstone crop high up the mountain slope with a 50° southeast dip. The iron sandstone at *Linn's mill* makes a high ridge, in prolongation of Conecocheague mountain, with oölitic ore a few inches thick. **Liberty valley** is bounded on the northwest by the Tuscarora axis and a rugged ore sandstone ridge with poor ore, dipping 40° southeast; at the northeast end of the valley the ore seems already to be passing from its oölitic to its sandstone form; it is oölitic with few or no fossils along the southeast flank of Conecocheague mountain. Southeast of Germantown Buck ridge arises gradually with an ore sandstone crest between two flanks of ore sandstone; the ridge is 4 miles long by 200 feet high at its highest point. Opposite *Andersontown* Sherman's creek cuts three times through a similar ridge 150 feet high and ten miles long without a sign of fossil ore. On *Bower's mountain* no fossil ore was seen. **Throughout the Sherman creek country** it is rarely seen and is then of no value. The XVII anticlinal east of Landisburg and south of Perry furnace throws the iron sandstone up around the east end of Pilot Hill (Formation IV) as the crest of a curious isolated lunar ridge. The XIV and XV anticlinals flatten out **Shœffer's valley** southeast of Bowen's mountain, but produce no ore. In **Kennedy's valley** the iron sandstone forms rugged knobs but has no fossil ore. Nor is there any fossil ore along the Blue (or Kittatinny) mountain from the Susquehanna gap to McClure's gap; nor in **South Horse valley.**

Southwest of the Juniata at Mifflentown, two long thin curving parallel canoe-shaped anticlinal mountains, Blue Ridge and Black Log, contain the red shales of V with the fossil ore upon their flanks and ends. The ore sandstone forms a distinct ridge at the Juniata, soon lost in the flanks of Blue Ridge. At Hardy's bank the ore was sandy and poor, 18 or 20 inches thick (tried at Montebello furnace), just over the highest layer of ore sandstone. Forge ridge, forking over the east end of Blacklog mountain, is made of iron sandstone; the ore sandstone 20 feet thick rests on its flanks and is seen at Jacob's ore bank on the river above Mifflintown. The ore itself rests on the sandstone as a heavy, square-splitting layer 2 feet thick, red and fossiliferous, very silicious and full of silex crystals at the joints. Two lines of outcrop traverse Licking Creek Valley from end to end, but no good ore is found.

Tuscarora mountain is bordered by the ore on both sides but it exists only in a state of ferruginous sand rock. No ore is seen at Shade gap nor at the Burnt Cabins although the sandstone is 20 to 30 feet thick and well exposed.[9]

The great Lewistown or middle Juniata Valley is on the contrary rich in ore, brought up by numerous anticlinals, as well as on the southern flank of Jack's mountain. The Lower or block ore in the lower slates of V, light brown and sometines slaty, is usually too silicious to work; it is abundant along the base of **Shade mountain** and near Middleburg, 1¼ miles east of Beaver furnace, where it is seven feet thick and very good, cropping out within 100 yards of the upper or fossil ore and dipping 30° north, over the red and grey ore sandstone 30 feet thick. Under this sandstone another stratum outcrops (40 yards across the surface from the block ore) a still lower stratum of encrinal birdeye ore 12 inches thick. In this eastern division of the Lewistown Valley the fossil ore does not seem to exist in force, and when found is a granular quartz rock with a yellowish brown ferruginous cement, weathering in rounded fragments. One belt of it ranges near the base of Shade and the other near that of Jack's mountain towards the southwest, the latter bending round the southwest end of Jack's mountain returning along the northern side of Standing Stone, sweeps around in a broad curve along the foot of Tussey mountain, southwest, past Huntingdon and Bedford into Maryland and Virginia.

Workable ore is not seen along **Shade mountain** between near Beavertown and Lewistown.[1] West of Lewistown in Furguson's valley it occurs and is used by the anthracite furnaces A 92 and A 93. The anticlinal ridge from Lewistown **back of Waynesburg** is formed by the ore sandstone with its ore, 150 feet high, wide and barren; the ore lying directly on the sand rock and under olive-colored shales; only 4 to 5 inches thick in some places but easily stripped, dipping 10° to 20°. Sometimes there are 2 layers each 2 to 3 inches thick as at Stroud's mill east of which they are 6 inches thick and lie horizontal. At Waynesburg the dying axis lets it gently down. Below Waynesburg the river and canal expose two layers only 2 inches thick, hard and calcareous. Beyond Brightfield's run at Worrell's banks a layer 3 to 5 inches rests on the sandstone, 15° S.E.

Along Blue Ridge runs the outcrop of the sandstone, as *e. g.* through the Blue Rock cliff east of Waynesburg, where it is 30 feet thick with calcareous layers, and the fossil ore, instead of being on top of it, is in its midst, thin, hard, calcareous, reddish brown, dipping 55° N.W.—At the southwest end of Blue Ridge mountain in **Germany valley,** the sandstones thicken and inclose three layers of fossil ore each 5 or 6 inches thick, difficult to mine, dipping 40° southeast.

At Matilda furnace a lower layer 8 inches thick rests on the top of the sand-

[9] Final Report, pp. 370–371.

[1] F. R., p. 411.

stone, and is so sandy as to produce out of 6 tons but 1 ton of metal, with 600 bushels of charcoal, although it looks like other fossil ore. Four inches of olive shale separates from an upper layer 10 inches thick of good fossil ore, yielding $2\frac{1}{2}$ to 1.

In the Little Cove near the Maryland line the iron sandstone and ore sandstones are enlarged to 30 or 40 feet thick each, separated by 75 feet of olive and buff slates, in which the fossil ore occurs. Some of the sandstones have grown very massive; the rock is white, fine-grained and hard with fucoidal impressions on the surface; the iron sandstone is dark red, massive, parted with red shale, and also pitted with lenticular fragments of red shale, washing out. On the west side of the basin they dip 30° S.E. and stand vertical on the other.[2]

Returning to the Juniata Huntingdon Region the ore sandstone ridges line the base of Standing Stone and Tussey's mountain from the Lewistown-Bellefonte turnpike to the Maryland line and so on into Virginia; the calcareous ore shales forming real clay limestone beds. At Goshen run gap east of Huntingdon in Stone mountain in the lower slates, ore was supposed to be struck. The sandstone is thinner here than in the Lewistown valley, soft, compact yellowish grey, rotting soon, and full of encrinites, underlying the ore at Dorsey's and at Green's banks, but apparently overlying another bed of ore at other places. On the canal below Huntingdon the ore was found four inches thick, 75° dip 225 feet below the bottom of the red shale. At the head of Standing Stone creek, Alexander and Diarmid found on an anticlinal from the **Seven mountains** soft fossil ore 20 to 30 inches thick. Dorsey and Green's principal banks half a mile northeast of the forge shows ore 18 inches thick, hard, calcareous, square, 40 per cent, 25° S. 40° E. *over* olive shale and *under* massive encrinitic sandstone. Further southwest a 32 per cent ore *over*lies the sandstone. The ore-outcrop zigzags along the base of Tussey mountain north of Huntingdon over numerous short anticlinals issuing in echelon from the mountain; the last one crosses the little Juniata at the forge and the main Juniata one mile west of Alexandria, continuing thence along **Hartzlog and Woodcock valley,**[3] where it suffers smaller flexures nearly parallel with the mountain, which repeat its outcrop. Between McConnelstown and Yellow creek it has been opened lately in many places, with a rich soft outcrop in several layers, averaging ten or twelve inches. Savage's banks opposite Trough creek is said to have yielded 20 to 24 inches of ore *under* the encrinitic sandstone, more slaty and more fossiliferous than at Danville. **At Yellow creek** opposite Hopewell furnace the outcrop doubles, is 2 feet thick, and is itself double with sometimes 8 feet of shale separating its two members, the lower of which is hard calcareous, the upper analyzed 55 per cent iron at the surface and $38\frac{1}{2}$ below the softened outcrop. **All along Tussey mountain** the dip is disposed to be steep, = 30° to 50° S.E. At Davis' banks south of Yellow creek the ore is still 2 feet thick in the upper stratum and 22 inches in the lower—eight feet apart. Burkett's and McDowell's banks show three beds, the uppermost three feet thick under olive slate and over sparry sandy limestone 8 feet thick, under which lies the middle ore bed, thin, calcareous, silicious, over fossiliferous olive shale one foot thick, under which is the lowest ore bed 2 feet thick, the best ore of the three, 27.72 per cent iron. On the creek above are seen two beds the thick upper bed 22 inches, very calcareous, 30° west. At Cogan's banks ten miles from Bedford forge a brown cellular stratum 4 feet thick was reached by a shaft 100 feet deep. Judge Dougherty of Bedford is said to have opened the outcrop (1858) along the mountain foot, and proved good ore in

[2] F. R., p. 416. [3] F. R., p. 516.

many places. The encrinitic ore sandstone,[4] separates from the mountain slope on passing **Bloody Run** and increases in height as a separate ridge until it enters Maryland, covered with great ochreous blocks.

The last Outcrop of the Fossil ore before sinking beneath the great coal regions to emerge in middle New York and middle Ohio, runs along the north foot of the Muncy, Bald Eagle, Dunning or Will's mountain, from Muncy past Bellefonte, Altoona and Hollidaysburg to Cumberland in Maryland. It is a grand curve broken at Hollidaysburg by a recess and near the Maryland line by some anticlinal axes. Everywhere except near Hollidaysburg the rocks are steep, sometimes nearly vertical. At the southeast end and not far therefore from Danville, Mr. McKinley reports the following section[5] translated by Mr. Rogers into his own nomenclature thus:

Meridian sandstone (VII Oriskany), very thin.

Slates, upper cherty, lower shaly buff,		60 feet
Premeridian limestone (VI lower Helderburg)		150 "
Scalent limestone, thin, blue, Cytherina alta,		100 "
Grey marls (Moore's quarry Lewisburg),		300? "
Blue shales; thin limes; black slates		200+ "
Grey marls, green, purple; flag limestones		100? "
Blood spot shale, below Milton		1000? "
Variegated marls, red and green, Muncy bridge		20 "
Surgent red shale		350 "
Upper Calcareous shale		230 "
Grey and greenish shale	Cytherina	·40 "
Limestone, Beyrichia, Calamopora	Atrypa	65 "
Greenish and buff slates	Avicula	65 "
Slates and ferrug. limes; 4 or 5 impure **ore beds,**		60 "
Lower calcareous shale, 5 miles below Jersey shore		110 "
Greenish shale, calc. bands, Agnostis hemicripterus, Upper slate, branching fucoids. and small fucoid, Iron sandstone, **ore bed,** of unknown place and size Lower slate		700 "

The lower silicious ore is discoverable at many points along the base of the **Bald Eagle mountain** and has been used at Margaretta furnace at Williamsport lately. In Bald Eagle

[4] According to the assistant geologist Dr. Jackson, who reports to Mr. Rogers in the Final Report, p. 525.

[5] Final Report i. p. 535.

creek valley at Howard Iron Works it has been successfully mined, outcropping half way up the mountain and dipping 70° N. 30° W. 60 yards east or under the fossil ore. In 1852 it was 22 inches thick and about 28 per cent iron. The Iron Sandstone outcrops higher up the mountain slope. The Ore Sandstone is wanting, or only represented by a few thin bands of grey sandstone. The grey calcareous sandstones also are absent from among the fossiliferous ore shales. But the Ore Sandstone comes in again in great force as we advance into Bedford county.

The Lower Ore Shales, **at Jersey shore** are well exposed 110 feet thick containing the small branching plant *buthotrephis gracilis*, and the Beyrichia, Hemicripterus and other fossils. Of the eight or ten thin fossiliferous ferruginous limestone beds four or five contain enough iron to be called ore beds but are only from 2 to 4 inches thick.[6] Further towards Muncy the ore is thicker and better and used at Williamsport furnace. Traced southwestward the upper shales on reaching the Potomac river have dwindled to a few feet thickness, with layers of sufficient size and purity of ore to be mined. One of the marked features of the formation in the Susquehanna and Bald Eagle valleys is the limestone stratum 60 feet thick, and 100 feet above the ore beds, containing shells in multitudes as large as hickory nuts. The *beyrichia seminalis* is most characteristic; Rogers mentions also *cytherina alta*, *atrypa lacunosa*, *calamopora*, etc.[7] At Danville this limestone is but 15 feet thick. Some of the same fossils occur in the 40 feet of green and grey shales over it up to the bottom of the red shales proper.

Along the Little Juniata approaching Altoona Mr. Burroughs owner of Blair furnace has opened the fossil ore bed from 10 to 15 inches thick in its main stratum with one or two small riders, in several places, as opposite Baker's hematite ore quarry and at the Altoona Spring at the mill in the Gap. **At Frankstown** however are the principal exhibitions of the ore, lying nearly flat, and reached by gangways. Here are seen, along a small stream, on the tramway from the mines, two beds of ore and limestone 3 or 4 inches thick separated by a foot or two of green shale, and overlaid by green shale under several thin limestones, under a great mass of red shale. Descending

[6] Final Report, p. 537.

[7] Final Report, p. 537.

in the order of the strata, dipping 10° to 30°, and ascending the stream, the mine tunnel shows the lower series of ore beds, 3 or 4 in number, under a massive sand-rock, and subjected to a dead fall fault of 16 feet, the fracture running north and south and cutting off the right hand gangway, running northeast. Ascending the stream far enough to bring us, say 600 feet beneath the ore, we find blocks of the lowest rock ore 3 feet thick made up of coarse sand-grains coated with ore and making a true oölite, with fossil shells adhering to one of the surfaces in immense numbers. It has nowhere been found in place, but underlies a great mass of red sandstone.

Mr. Rogers gives the following section of the Hollidaysburg beds, as taken from the railroad cutting near the town, where they appear very thin and thrown down by several small faults, —*descending:*—One 8 inches,—Strata concealed by the street,—Fossil Limestone bands,—Blue and green calcareous slates and other shales for several hundred feet,—Ore Sandstone,—Ore 6 inches,—Shales, etc.—Ore impure 12 inches,—Shales,—Ore 3 inches,—Shales,—Ore 3 inches,—Claret and green shales, —all dipping 30 degrees.[8]

The fossil ore runs all round the inside border of Frankstown cove or the Hatchet, and passes southwest from Hollidaysburg towards Maryland in its usual position near the base of the Bald Eagle mountain, now Dunming's mountain, and beyond Bedford Will's mountain. **Bedford** lies in a synclinal valley of Devonian rocks with Upper Silurian on each side in which the fossil ore ought to appear but does not in any workable amount. In fact we must pass on to the Potomac before we find it again in force. There, on both sides of **Cumberland** runs its double outcrop attacked at various points for the furnaces in that neighborhood. Dr. Jackson says[9] that the principal change going south consists in the red shale formation becoming more silicious, becoming in fact a red sandstone, and thickening so as to form a considerable ridge through Maryland. A few massive beds of grey sandstones then begin to add themselves with beautiful fucoides like twigs of bushes. Between this ridge and the mountain of IV runs the low yellow sandstone ridge with the fossiliferous ore group on its side.

Through Virginia the fossil ore of V ranges along the base of the **Knobly,** the **New creek,** the **Patterson creek,** the

[8] Final Report, p. 730. [9] Final Report, p. 567.

Capon, the **North fork,** the **Props gap,** the **South branch** the **Warm spring,** the **Bull pasture,** and the **Back creek mountains**—west of the Great valley;—and in a similar way round the inside edge of the synclinal valleys of the **Massanutten range** east of the Great valley.[1] No details, however, are afforded by the geological survey of the State, and we must rely upon Mr. Lyman's report to the secretary of the American Iron Association in 1858, for the following facts.

In Hampshire county; Vulcan furnace (H 174) six miles southeast of Cumberland. ran wholly upon this ore.—Trout run furnace, in the Devil's Hole, is in ruins.—The Fort furnaces do not use the fossil ore.—Other furnaces that used some fossil ore have ceased making iron. Not a furnace now running in the Great valley, until we come to the Tennessee line, uses the fossil ore.

In Tennessee all the furnaces on the west side of the Great valley under the great escarpement of the Cumberland (Alleghany) mountain, use fossil ore in whole or in part.

In Hancock county; Overton's forge blooms dyestone ore from the ridge just north of it.

In Claiborne county; Cumberland gap furnace (H 276), in the celebrated pass of the mountain into Kentucky, by which Boone and all subsequent settlers from southern Virginia and the Carolinas penetrated to the western wilderness, has the outcrop of the fossil ore within 500 yards, extending in a ledge along the mountain, 30 inches thick. Specimens from these openings cannot be distinguished from specimens from Danville or Frankstown in Pennsylvania. Five miles northwest of it "are inexhaustible mines of bituminous coal."—Belleville furnace (H 277) and forge (I 389) on Indian creek five miles west of the gap, has a length of outcrop of eight miles at its command, with openings all along, the ore soft.—Little Barren forge gets its dyestone five miles south near Howley's ford.—Speedwell furnace and forge in Campbell county, and Sharp's in Granger, are abandoned.

In Campbell county; Centreville forge (I 391) five miles east of Fincastle, gets its dyestone from north-northwest and west of it.—Baker's forge on Cedar creek, gets its 25 per cent dyestone from William's bank six miles northwest of it.—Richardson's forge on Big creek, uses 23½ per cent dyestone ore from a bank over a mile northwest of it.—Sharp's furnace is abandoned, but the new forge on Big creek uses dyestone found all along the mountain near it.—Queener forge on Cove creek has a bank four miles north and plenty of ore in its vicinity.—Lindsay forge on Cove creek uses the same bank.

In Union county; Miller's furnace (H 380) on Buffalo creek has openings on the outcrop of the ore two miles and a half mile east and half a mile, a mile and two miles south.

In Roane county; The Eagle furnaces (H 381, 382) opens the outcrop of the fossil ore as it runs along the south side of the Tennessee river, in a southwest direction, from 16 to 20 inches thick, yielding 60 per cent of iron. with a dip of 30° to the southeast, two miles in a direct line from the furnace. The furnace is therefore in the range of a fault or anticlinal axis, and the parallel outcrops of the dyestone through east Tennessee are colored on Safford's geological map.

[1] W. B. Rogers's Second Report, pp. 50, 73.

The lower block ore 30 per cent bed, making soft iron, runs within a quarter mile of the furnace. The Jackson ferry opening, four miles east, shows the upper bed to be from 20 to 24 inches thick, averaging 50 per cent, 60 per cent after roasting, and "80 per cent by analysis."—Piney grove furnace was abandoned in 1828.—Gordon's forge, on White's creek, has its banks up and down the foot of Warland's ridge.—Eagle forge No. 2, two miles south of Gordon forge, uses Jackson ferry bank, four miles east of it.—Turnpike creek forge uses Gordon's bank 25 per cent ore, three miles north of it.—Montgomery's White creek forge, in Warland ridge gap, has 20 or more openings on the bed at the foot of the ridge.—Kimbrough's Turnpike creek forge has several openings close by; that from the bank nearly a mile south yields 60 per cent, and, if carefully worked, 1,000 to 2,240 lbs. in the bloomary. Troost's analysis of Gordon's and Kimbrough's ores is: Peroxide iron 93, carbonate lime 3.5, alumina and silica 2.[2]

In **Rhea county**; Upper Piney creek forge uses Waterhouse's bank, one and a half miles north, averaging 600 lbs of iron from 2,240 ore; and Halloway's bank, one mile north-northwest, of the same quality. There are some 50 openings in Shinbone ridge, in the three miles north of the forge.—The lower forge uses Waterhouse ore, two miles northwest, and three or four other nearer banks.

In **Meigs county**; the abandoned Farmer's (Sue creek) forge used dyestone from a bank nearly a mile west of it.

In **McMinn county** the dyestone ore comes up on anticlinal faults, and Cooke's forge (I 387) on Connesaugua creek, 13 miles southwest of Tellico furnace, has a bank 5 miles northwest of it.

In **Hamilton county**; Bluff furnace (H 284) on the bank of the Tennessee in Chattanooga, gets its fossil dyestone ore from Jackson's bank, 60 miles up the river, 3 miles south of Eagle furnace, as already said. It is a 50 per cent ore, costing 20 cents a ton to raise, 30 to haul to the boats, and $1 50 to deliver at the furnace.

In **Alabama**; **Cherokee county**; Round mountain furnace (H 252) uses 40 per cent dyestone fossil ore from a bank 200 yards west of the furnace.

In **Ohio**, near Zanesville Muskingum county oölitic iron analyzed by Foster in 1837 gave: Peroxide iron 50.424, earths 24.888, water combined 21.100, uncombined 1.500, lime 0.112, etc.=100.00.[3]

In **Eastern Kentucky**, Bath county, Slate furnace was formerly run upon the oölitic ore of V, associated with the magnesian limestone (of the Clinton group), and here more silicious than usual. The old furnace went out of blast in 1838 after running 47 years.

In Estill county, six miles northeast of Irvine, on Searly King's farm, small quantities of sulphuret of copper and iron are found disseminated in an orange-yellow magnesian limestone, either of the age of the Clinton group, or in rocks of the same

[2] Fifth Report, p. 41, 1840. [3] Mather's Report 1838, p. 39.

composition immediately under it. No axis of disturbance is known in the vicinity.[4]

In **Wisconsin** this ore rises from beneath the Illinois coal fields and Lake Michigan, in a curve the convex side of which is towards Chicago. In **Dodge county,** Mayville furnace (K 624) is four or five miles from the Iron Ridge ore bed and 40 miles from Lake Michigan. The La Crosse railway cuts the ore bed (in the town of Hubbard, Sec. 10, 12), which is a layer 10 feet deep over 500 acres, "containing 27 million tons." Or, as Prof. Daniel again describes it, its outcrop is a mile long, and thickest at its east or lowest end, where its limestone covering is gone and the ore is decomposed to a sand or seed-ore mass 25 to 30 feet thick. The size of the grains ranges from mustard seed to swan shot, irregular, oval, glistening red, greasy, staining the touch; evidently concretions around grains of silex; without fossils; cemented, stratified, cleft and jointed; grains laid parallel to the planes of bedding. Occasionally occur more recently formed nodules of compact brown hematite. *Under* it, is first, a layer of soft blue ("Nucula") shale (see Daniel's Rep. of 1853), and then hard blue limestone of Clinton (Formation V) age. *Over* it are coarse, cavernous, magnesian limestone layers which once contained the iron and from which it has leached down. The analysis by C. T. Jackson, of Boston, shows that its coldshort quality is due to silica. Peroxide iron 72.50 (=50.77 metal), alumina 8.40, silica 7.75, oxíde manganese 1.40, magnesia .64, lime 5.60, water 8.75. Two and a quarter tons of ore, allowing for waste, make a ton of iron, as at Hollidaysburg, Pennsylvania.[5] The first experiments gave the ore a bad name. Extensive mine works are preparing for an extensive future demand. The amount of ore is unlimited. The same kind occurs 14 miles southeast in Washington county at Hartford, 6 to 7 feet thick, 15 feet under ground; also eighty miles north-northeast 4 miles east of Depere, 7 miles southeast of Green Bay, 4 miles from steamboat landing, 6½ feet thick, at the falls, where is a fine site for a furnace owned by James Howe, of Green Bay, and D. M. Loy, of Depere.

[4] Owen's Kentucky Report. [5] Bulletin Amer. I. Assoc., notes, No. 135, 139, p. 80.

CARBONATE.

CHAPTER IV.

THE CARBONATE ORES.

Whatever theory of iron-ore-origination or iron-ore-metamorphosis we adopt, the fact is patent to theorists of every sort and to those who will not theorize upon the subject, that a great change comes over the aspect of the ore-world when we ascend the scale of rocks and ages and reach a comparatively later stage than that of the Cambrian and Silurian eras. No longer magnetic and specular iron veins present their enormous and unsteady wedges among granite hills, loaded with curious and brilliant minerals. No longer vast deposits of brown hematite beneath a covering of gravel-drift follow the outcrops of the older limestones. There come instead to view innumerable thin but wide extended sheets of protocarbonate of iron, alternating with slates surcharged with carbon and sulphur, and with flagstones full of vegetable stemcasts but almost destitute of higher types of life. This new form of iron meets us first in any great abundance at the beginning of the Devonian age, recurs at long intervals during its elapse, makes one of its most brilliant exhibits at the opening of the Coal era, through which it reigns supreme, reappears with the coal measures of the Middle Secondary or Triassic age, and finishes its mission in the tertiary strata underlapping the sea coast.

The first important fact afforded by this series of phenomena is this: that the **age of carbon opens in both forms, organic and chemical, at once.** Plants and animals appear in abundance when carbonate of iron appears in workable layers. How far this is a coincidence based on a relation of cause and effect is not yet well made out. Some see a closer and more necessary dependence of the carbonation of the ore upon the carbon set free from the dead organisms than others do; and the few expressions of various opinions which follow here will suffice to show how fruitful a field of experiment as well as conjecture that on which we enter can be made.

The precise method of formation of the imbedded protocarbo-

nate of iron is in fact still a mystery. Evidently deposited in an ocean like the other coal measures, they should have been thrown down one would think in the form of a red peroxide powder. But none of the present waters of the earth are charged with iron to such a degree as to make deposits of the extent of some of these a possibility; and what is deposited is also mixed with sand and mud, its chief source being the decomposition of such silicates as the augite and hornblende of various traps and schists, the clays of which sometimes contain one-third their weight of iron oxide.

Mr. H. C. Sorby of Sheffield in a memoir on the subject read before the Geological Society of the West Riding in 1856 has supported the theory that all the iron-stone deposits may have once been strata of carbonate of lime, covered by ferruginous clays containing organic matter producing bicarbonate of iron, which, when carried down through the limestone, has removed a large part of the same, leaving in its place carbonate of iron. His example is the Cleveland hill iron-stone, quarried near Middleborough, containing shells, some of them unchanged, others changed to carbonate of iron. The microscope reveals yellow obtuse rhombic crystals of carbonate of iron shooting into the shells a variable distance, sometimes leaving the interior an unchanged clear colorless carbonate of lime. What could be done to a shell, he argues, could be done to a stratum. An analysis of a shell from the Inferior Oölite gave carbonate of the protoxide of iron 78.0, carb. lime 5.2, carb. magnesia 3.1, peroxide of iron 10.9, water 2.1, carbonaceous matter 0.1, quartz 0.6. Originally such a shell would consist almost entirely of carbonate of lime; now it is more than three-fourths carbonate of iron. The Cleveland hill ironstone is seen under the microscope also to be oölitic, with small fragments of shells and patches of fine granular matter like many oölitic limestones. It consists chiefly of the carbonate, and contains also silicate and phosphate of the protoxide of iron (to which it owes its green color), with smaller quantities of carbonate of lime and magnesia, some alumina and peroxide of iron.[6] We know that phosphate of iron is produced by the action of bicarbonate of iron on phosphate of lime. The silicate of iron present might be formed by the protoxide of iron

[6] For the analysis see the Iron Ores of Great Britain, Part I. of the Memoirs of the Geological Survey.

either replacing the alumina of the clay, or decomposing silicate of lime.

This is one theory.[7] Another and precisely opposite one is that which asserts the possibility of all these beds having been deposited as peroxide of iron, and then supposes them changed by the carbonic gases from decaying animal and vegetable matter into beds of carbonate of iron. The latest expression of this theory is given by H. D. Rogers thus:

Respecting the origin of carbonate of iron in these ores, it is sufficiently evident from the texture of the nodular ore itself and of the slates surrounding it, that the whole mass of each ore-bearing bed was primarily deposited as a fine calcareous and ferruginous mud, in which was included a large amount of organic matter, especially the fragments of the carboniferous vegetation, and in some cases certain species of shells. In these deposits the iron was at first probably in the state of peroxide, as in nearly all finely-pulverized and long-exposed sediments. By the slow decomposition of the organic materials, a part of the oxygen of the peroxide would be withdrawn to combine with the carbon and hydrogen of the organic substances, and the iron would be thus left in the state of protoxide. At the same time the carbonic acid formed by the oxidation of the carbon would unite with the protoxide, and give rise to the protocarbonate of iron. As long as any organic matter remained in the mass, this change would continue, and in this way the whole of the peroxide of the original sediment may be conceived to have been converted into carbonate. The same action now continuing, though in a slighter degree, must tend to protect the carbonate from the decomposing action of the atmosphere, and thus in many cases to retard its conversion into the brown oxide. The nodular form of the ore is evidently a subsequent result and must be referred to the agency of a concreting force among the particles by which the carbonates of iron and lime, previously diffused in a uniform manner throughout the mass, have been gathered around certain centres. Some of the superficial beds of brown ore resting upon the outcrop of the coal rocks, would seem to be derived rather from the sulphuret of iron diffused in the adjoining slates, as in cases previously mentioned, than from the decomposition of the nodular carbonates. These have nothing of the continuous regularity of the layers of the nodular ore, and they bear a strong resemblance to the loose ore deposit of the older Appalachian slates. In further elucidation of this interesting sub-

[7] Volger remarks how noteworthy it is that no observation is recorded of spathic iron replacing the lime of organic remains, as of molluscs, crinoidal joints, etc., although great attention has been paid by Blum and others to the comparison of the petrifying agents. Speyer was the first to discover the pseudomorph of spathic iron after calcspar, described by Blum * in Leonhard and Bronn's Jahrbuch der Mineralogie, 1851, p. 398. Calcspar rhombohedrons in drusy cavities in Anamesite are clad with a thin fragile rind of ironspar, from which project thin ironspar lamellæ. The agent was probably water holding not only ironoxydulsesquicarbonate but also free carbonic acid. Sandberger and Sillem describe other cases; the latter, one of sharp rhombohedrons (R + 3) of calcspar turned to brown-yellow nodular carbonate of iron, lying on a piece of nodular carbonate penetrated with little crystals of sulphuret of iron; the rhombohedrons being hollow, and warty-drusy outside.†

* Pseudom. p. 304. † Volger's Studien, p. 23.

ject, I take the liberty of introducing here a valuable brief essay on the origin and accumulation of the protocarbonate of iron in coal measures, etc., by Professor Wm. B. Rogers.

This compound, as we know, where mined in the coal measures, presents itself in courses of lenticular nodules and interrupted plates usually included in carbonaceous shales, and in the fire-clays which underlie the seams of coal, and in such cases it often forms a heavy ore containing but little earthy or organic matter mixed with the protocarbonate; but it is also frequently met with in a *diffused condition*, pervading thick strata of shale and shaly sandstone, and causing these rocks to present in their different layers all the gradations of composition from a poor argillaceous and sandy ore, to beds of sandstone and shale, with little more than a trace of the ferruginous compound. On comparing the different subdivisions of a system of coal measures, we may remark certain general conditions connected with the abundance or with the comparative absence of the protocarbonate in the strata.

One of these is seen in the fact that *the lenticular ores and strata impregnated with protocarbonate of iron are in a great degree restricted to such divisions of the carboniferous rocks as include beds of coal, or are otherwise heavily charged with carbonaceous matter.* This is well known on comparing together the four subdivisions of the carboniferous rocks of the great trans-Alleghany coal region, as classified under the head of the Seral Coal Series of the Pennsylvania and Virginia geology. In the first of these, designated as the older coal measures, the protocarbonate is found in larger amount, both in the shape of layers of lenticular ore, and diffused through the substance of the shaly strata. In the next division above, distinguished as the Older Barren Shales, and which, as the name implies, is comparatively devoid of carbonaceous matter, much less of the protocarbonate is met with. In the third group, that of the newer coal measures, the ore again abounds; and in the uppermost division or Newer Barren Shales, it has a second time almost disappeared. The connection between the development of the protocarbonate in the strata, and the presence, either now or formerly, of a large amount of carbonaceous or vegetable matter, becomes even more striking on a detailed examination of particular beds. Thus in the coarse sandstones of the coal measures which are comparatively destitute of vegetable remains, we find little admixture of the protocarbonate. On the other hand, the fine-grained flaggy argillaceous sandstones, which are often crowded with the impressions and carbonized remains of plants, are at the same time more or less impregnated with this ferruginous compound. So again, the soft argillaceous shales, in the midst of which the lenticular ore so frequently presents itself, show by their dark color and included impressions of plants, as well as by actual analysis, that they are richly imbued with vegetable matter. Nor do the nearly white fire-clays, which in many cases inclose thick courses of the lenticular ore, form any exception to this law; for although in their present state, they contain little or no carbonaceous matter, the marks of innumerable roots of Stigmaria, and parts of other plants which everywhere penetrate the mass, show that at one time they must have been crowded with vegetable remains.

A further and yet more striking proof of the influence which the contiguous vegetable matter has had in the formation of the protocarbonate is seen in the fact that the most productive layers of the ore are commonly met with quite near to the beds of coal, and that frequently courses of the nodules are found in the carbonaceous shales or partings which lie in the midst of the seam itself.

While the strata, including the protocarbonate, are thus distinguished by the ad

mixture of more or less carbonaceous matter, they are *also remarkable for seldom exhibiting a distinctly red tint.* Presenting, where not weathered, various shades of greenish-grey and olive and bluish-black, they only become brown or red where, by exposure to the air, the protocarbonate has been converted into the sesquioxide of iron. On the other hand, those divisions of the coal measures which have been but slightly charged with vegetable matter—as, for example, the Barren shales of the Seral coal rocks before alluded to—contain much red material both in distinct strata and mottling the general mass, and are throughout more or less impregnated with the sesquioxide. A like general law as to color would seem to apply to the other great groups of sedimentary rocks which include, in particular beds, accumulations of vegetable or other organic exuviæ. Thus in the new and old Red-sandstone formations, which generally include so large a proportion of sediment colored by the red oxide of iron, organic remains are of comparatively rare occurrence, and, when present, are met with almost exclusively in the grey, and olive, and dark-colored strata which are interpolated in certain parts of the great masses of red material. This relation is beautifully shown in the middle secondary rocks of the Atlantic Slope, which extend in a prolonged belt from the Connecticut valley into the State of South Carolina. In the strata of red sandstone and shale which form the chief part of the mass, vegetable or animal exuviæ are almost entirely absent; but the remains of fish and impressions of carbonized parts of plants occurring in this group of deposits are found imbedded in layers of greenish and olive sandstones and dark bituminous shales. So in the south parts of the belt in Virginia and North Carolina, where these rocks include seams of coal and extensive beds of sandstone and shale, containing the remains of plants, the usual red color is found to give place to the grey, olive, and dark tints of the old coal measures, and layers of proto-carbonate of iron show themselves in the vicinity of the coal seams. Taken in mass, the red and mottled strata of the unproductive coal measures, or of the other groups of red rocks above alluded to, would no doubt be found to contain, in an equal thickness, as large an amount of iron as the coal-bearing strata which include the layers of carbonate—the difference being, that in the former case the metal remains for the most part diffused through the rock as a sesquioxide; while, in the latter, having assumed the condition of proto-carbonate, it has to some extent been concentrated in particular layers or strata. According to a rough estimate of the amount of carbonate ore included in the lower Coal-measures of the Laurel Hill region of Virginia and Pennsylvania, derived from a detailed examination of the ores and associated strata at several points, it may be safely assumed that the equivalent of sesquioxide of iron would not amount to one-third of one per cent of the whole mass of this portion of the coal measures, and a proportion not exceeding this is deducible from the measured sections of ore and accompanying rocks in the carboniferous strata of other tracts subjected to a similar calculation. But even allowing a quantity three times as great as this to cover the diffused carbonate, and the oxide in some cases mingled with it, we should have only about one per cent to represent the proportion of ferruginous matter in the entire mass—an amount undoubtedly much less than what exists in many of the strata of red and purple shales and shaly sandstones of the carboniferous series, or of the groups of red rocks geologically above or beneath it.

In attempting to explain the origin of the protocarbonate under the conditions above described, it is important to keep in view the fact of the diffusion of this compound through many of the strata as a general constituent, and the frequent preservation even in layers of the ore of the lamination of the contiguous rock.

The supposition of its being a chemical deposit formed from springs charged with carbonic acid, and holding protocarbonate in solution, is evidently inconsistent with these conditions, and not less so with the fact of the great horizontal extension of individual beds of ore and impregnated shaly rocks. In view of these various considerations it may be concluded—

First, That throughout the coal measures and other groups of rocks above mentioned, as well in the portions containing coal and diffused vegetable and animal matter as in the barren parts, the original sediment was more or less charged with sesquioxide of iron; and,

Second, That this sesquioxide in the presence of the changing vegetable matter with which certain of the strata abounded, was converted into protocarbonate, which remained in part diffused through these beds, or by processes of filtration and segregation was accumulated in particular layers.

It is well known that during the slow chemical changes by which vegetable matter inclosed in moist earth is converted into lignite or coal, both light carburetted hydrogen and carbonic acid are evolved, and that these gases are even eliminated from coal seams and their adjoining carbonaceous strata. The reducing agency of the carbon and hydrogen, as they separate in their nascent state from the organic matter, is capable, as we know, of converting certain sulphates into sulphurets, and even more readily of transforming the sesquioxide of iron into protoxide. The latter change would doubtless be favored by the affinity of the carbonic acid present in the mass, for the protoxide thus formed, and in this way the sesquioxide would be entirely converted into the protocarbonate of iron. Conceiving a like process to have operated on a large scale in the coal measures or other strata containing, when deposited, a mixture of sesquioxide of iron and organic matter, we have a simple explanation of the general conversion of this oxide into carbonate, and of the loss of the reddish coloring in which these materials more or less participated. As these actions must be supposed to have commenced in each stratum as soon as the organic matter contained in it began to suffer chemical change, we may conclude that the formation of the protocarbonate was already far advanced in the earlier strata when only beginning in those deposited at a later period. Each layer of vegetable matter, as it was transformed into coal, would not fail to impregnate the adjoining beds of shale and sandstone with the protocarbonate, and thus the development of this compound was, as it were, coeval with that of the coal. The gathering of the diffused protocarbonate into bands and courses of ore began, no doubt, as soon as the production of this compound had made some progress; but it probably continued until long after the completion of the chemical changes above described, and indeed it is possible that in some strata it is not yet entirely finished. In this process, which finds a simple explanation *in the combined action of infiltration and the segregating force*, it can hardly be questioned that *the carbonic acid* pervading the mass of sediment acted *a very important part*. The large amount of this gas evolved from the beds of vegetable matter undergoing change would impart to the water of the adjoining strata the power of dissolving the diffused protocarbonate, which being then carried by infiltration through the more porous beds, would accumulate above and within the close argillaceous or shaly layers, forming in some cases bands of rock ore, in others, courses of nodular and plate ores. Of these, the former would seem to have resulted from the accumulation by *gravity* of the dissolved carbonate in the substance of sandy shales near the upper limit of the more impervious beds, while we may regard the latter as having been collected in all directions from the general charge of protocarbonate accumulated in the argillaceous

mass, its mobility in the dissolved condition greatly aiding the gathering process of the *segregating force*.

The objections to this theory are severally these: first the relation specified of coal to iron is not precisely true in nature. Many beds of carbonate of iron are far removed from any fossil-holding rock or coal bed. In the vast piles of the olive Devonian sands and slates where hundreds of ore-ball layers occur, fossils are almost unknown. It is true that the Devonian grey shales of the West are the site of the Kentucky knob ore, and overlie the black slates of which we can only imagine the black color to be in some way dependent on an unusual quantity of carbon, and we know of thin coal beds in them; but it is hardly to be supposed that the Larry's creek ore occurring one or two thousand feet above the black slates of the upper Susquehanna valley owe their deoxygenation to their carbonic acid or oxide gases.—Again the necessity of the *super*position of the iron to the coal or fossil-holding strata would seem an almost essential point of the theory; but how often, as in the ore of XI, does the iron lie ten, twenty, fifty feet below the coal or carbonized slates, and could hardly be supposed affected by their gases. Surely some fixed relation of position would be noticed between the two minerals if the one generated the other. On the contrary, sometimes on top, sometimes below, the ore bed now touches the coal, now removes itself to a distance, with sand, lime, clay between, in one or many alternate strata just as it may happen.—Then, the frequent repetitions of the plates of ore in a single homogeneous stratum of sand, or of clay, apparently regardless of the proximity or distance of a coal bed, show how little they were affected by the existence of any such. These repetitions are each perfect and complete, like any other stratum, and would certainly show all the steps of any change to which they had been subjected since their origin. Were they originally deposited as peroxide and then slowly metamorphosed by carbonic gas to a carbonate protoxide, they would, in the majority of cases, be seen arrested in this development at various stages of it; whereas the cases where this seems to be the fact are very few, and to be explained by the subsequent backward metamorphosis from carbonate protoxide to peroxide, as the theory is obliged to admit.—Finally, the composition of the stratum of a carbonate ore bed is so analogous, in fact so

identical with that of a carbonate of lime bed, the constituents are so similar, and replace each other with such frequency, rapidity and chemical *sang froid*, magnesia, soda, zinc and manganese coming in and going out like *habitués* of a club-room, all equally at home, all standing on the same platform of original rights, that it is impossible to regard the combination layer as anything but originally the compound deposit it is now.

The theory of carbonization has however found many supporters, and one lately in an unexpected and experimental way. M. Rivière has discovered the fact that common street gas escaping from the main, impregnates, carbonizes and in fact turns into a combustible coal-slate the mud through which it ascends to the surface of the ground. Through dry sand the gas escapes and leaves few traces; but when it must pass through a clayey, slightly damp ground, charged with vegetable or animal debris, especially if under a considerable thickness of upper strata, it then charges the mass, especially near the cracks and joints, increases its weight and even its bulk, and converts the vegetable matters into carbon (more or less bituminous) and the ferruginous matters into oxides, sulphates or sulphides of iron; probably (he says) if time were given and circumstances were favorable it would convert them into sulphurets and carbonates of iron.[8]

But it is one thing (and a very beautiful thing) to see layers of mud so *charged* mechanically with carbonized gases as to become carbonized shales like coal-black slate, and quite a different thing to imagine any such escape of gases to convert solid layers of peroxide of iron into plates of carbonate. Hence the theory trusts to the disseminated gases finding the peroxide, not in layers, but disseminated through the strata, converting it into carbonate of iron; and then the theory calls for waters holding more carbonic acid in solution to wash the disseminated new-made ore down to a common level on the upper surface of some mud stratum. This is a mere fancy, as any one will feel who counts the innumerable perfect layers of carbonate of iron in the rocks, remarking how they obey no such law of settlement. Every coal bed has a fire clay under it, for this was needful for

[8] Origin of bituminous schists, a paper communicated to the Academy of Sciences at Paris, Oct. 25, 1858, by M. A. Rivière. Franklin Institute Journal, p. 122.

its plants to grow in first,[9] or this was the sediment which its plants threw down. So if the above theory be correct, every bed of carbonate of iron should have a sandy or pervious mass of rock above it and a clay or impervious layer underneath it. An hour's observation of a cliff will dispel such a fancy if one has entertained it. There are no signs of this settling of the iron to a level, except in the case of true limonite beds, which, by the exception they offer to the rule of the carbonate beds, prove the rule of original deposition. There are certain beds of iron ore in the coal measures which bear all the marks of having been collected from the strata above and carried down upon the face of a clay or limestone stratum which in turn has itself suffered from the subsequent interchange of elements. Such is the great ferriferous or buhrstone bed ore of northwest Pennsylvania and Ohio. But the majority of ore beds show no mark of such action.

There is a third theory which calls to its aid volcanic gases to carbonize the iron ore beds in the coal formations. But this cannot stand a moment before the two objections that these beds are not local but continental in extent, and not only very ancient but quite recent productions of the life of the planet. It is true that that *general* connection between the coal and carbonate of iron which is acknowledged in the large by even those who deny it in detail, may be best explained perhaps by an over charge of carbonic vapors in the ancient atmosphere, originating at one and the same time carbonized sediments and an abundance of organic life. But the existence of an atmosphere of that peculiar volcanic type, once so favorite a part of the explanations by which geologists accounted for the ancient coal measures, is no longer generally believed in.

A fourth attempt to explain the perhaps inexplicable refers the beds of carbonate of iron to the same agency which distributed the beds of sand and mud, limestones and coal-plant debris, —to river water charged with carbonated and ferruginous spring waters, pouring into the shallow ocean the contributions of innumerable copious mineral springs and the detritus of all their water basins. Something must be granted to the subsequent readjustment and self-ordered stratification of these materials;

[9] See Lesquereux's admirable essay on the formation coal in Owen's Kentucky Reports, vol iii.

but how much, will perhaps never be found out. The finely comminuted and widely distributed decaying organic matter always carried out to sea by all rivers and held in suspension by all ocean currents has not been overlooked by geologists. Not going quite so far as Whittlesea, who will have it that the coal beds themselves are such infloated masses, they nevertheless recognize the enormous quantity of this decay. Its chemical eactions after being imbedded all over an ocean bottom and all through a hundred or a thousand fathom of wet sands and muds must be magnificent. The intellectual conception and arrangement of the products of such a laboratory may well confound the theorizing faculty. They can be studied only on the edges of the present deep and in an ignorance more or less complete of most of the circumstances under which they have resulted. Dr. Hayes of Boston has called attention to the electro-chemical agency of suboceanic springs of fresh water, rising in the midst of the shore detritus before and after its deposit.

The subterranean waters of the peninsula of Boston, have at the depth of about 140 feet, a remarkable uniformity of composition, and the flow towards the shore-line is abundant. Like the water of the lower Mississippi, they are turbid, holding in suspension finely divided carbonate of lime and iron, and hydrate of silicic acid; affording, when greatly heated, a precipitation of hydrated carbonate of lime, due to the instantaneous decomposition of sulphate of lime, by a solution of bicarbonate of soda present. The latter salt is in these cases always in excess; so that the whole mass of the drainage, at about the same level, has a marked alkalinity, and belongs to the class of alkaline waters. Numerous observations have shown that this water is covered by a compact marl-earth, which has so large a proportion of clay that it effectually divides the upper drainage from the lower, or alkaline water, which, from its depth below the surface, can enter the harbor water only at some distance from the shore. When attempts have been made by continuous pumping for many days, to exhaust the supply, or overcome the flow of the water at one point, the wells or borings at contiguous points have shown a reduction of volume in the water; but a reflux of the ocean water through the same channels has been effected only where, after several days, a very large volume of water had been pumped from one opening. This fact establishes our knowledge of a continuous flow of alkaline water towards the sea from the shore-line, while the depth of the stratum under which it flows, shows that it is overlaid by the mass of sea-water near the shore. A continuation of solid marl stratum below the water near the shore, would prevent any intermixture of the alkaline water with the sea water at that point, and allow it to gradually mix only when the soundings are about twenty-five fathoms. There is no cause apparent, which would prevent a continued suspension of the minutely divided matter, until the turbid water mixes with the sea water. In the cases of pumping referred to, the water, after some days, became more turbid than at the commencement of the trials, leading to the conclusion that turbid water occupied every part of the submarine channels of flow.

The occurrence of fresh water forced up from below the ocean, along the border

of our southern States, has been frequently described. I have observed phenomena in several places among the West India islands, illustrating this flow from the land under the water of the ocean, where the elevation of volcanic mountains was considerable.

The mere presence of fresh water at the bottom of the ocean infiltrating through the slime, or sand, would be sufficient to induce chemical changes by the disturbance of electrical relations. While the surface and mass of the ocean water, absorbing oxygen from the air, would be positive to a stratum of sea water mixed with fresh at the bottom, decompositions of oxidized bodies with simpler forms of matter would take place near the line where they blended. I am disposed to consider the presence of organic matter, either carried in solution from the land, or taken up from the salt and stirred by the fresh water, as the more active cause of decomposition of oxidized bodies. The formation of the sulphurets of metals, from metallic masses, which have been deposited at the bottom of the sea, on soundings, is more simply explained by this mode of action also. The existence of a drainage flow of turbid water, or a water containing bicarbonates of alkalies, or alkaline earths, along a coast line, would account for the green color of sea water on soundings near coasts. The division of blue water into many thin portions between reflecting surfaces, produced by the presence of suspended solid particles, alters its color to the hue which, by contrast, is called green. These solid, though finely divided particles, would be far more abundant in the case of the flow of alkaline waters, for the mixing of such waters with the ocean would be followed by the constant decomposition of the lime salts of the ocean water, and the production of carbonate of lime in a hydrous, gelatinous form, passing into the state of opaque particles, and precipitating continuously. A natural cause for the production of carbonate of lime, by precipitation from the lime salts held in solution by sea water, is thus acting along the coast line of this and probably other countries. The influence of the minute quantity of organic matter contained in drainage water in producing chemical changes of importance is rendered apparent, in this connection, by its power of decomposition of oxygen sources.[1]

The carbonates of iron undergo two changes subsequent to deposition, one mechanical and the other chemical, comparatively one ancient and the other modern. The first is into the nodular form, the second is into the brown hematite condition. A few words are here necessary about each.

Nodular iron ore is a form of the carbonate of the protoxide of iron found sporadic in the midst of sandstone or shale, and in layers, more or less compact, in all kinds of sediments, even in the bodies of coal beds, where the coal is much mixed with slate. It is almost always found in the shales or sandstones overlying a solid plate of the carbonate ore itself; and usually so that the nodules increase in number and size downward towards the plate, as if a plate itself was but the maximum of balls in a given space; in fact, many or most plates of ore may be mined in elongated tablets or huge balls flattened square against each

[1] Dr. Hayes in the B. S. N. H. See Annual of Sci. Disc. 1856.

other, and some of the finest exhibitions of ore are of such tabular masses nearly or quite touching, yet separated by fine white or variously tinted clay, in which the tablets of ore lie as it were imbedded. All this makes the chemical separation of the carbonate ore from the silica and alumina of the original clay deposit a matter of segregation around centres of attraction. Various opinions of the cause here at work have been expressed. There are five or six substances for which carbonic acid has similar affinities and they are always found grouped in these balls, as has already been said; but there are some reasons for believing that one of them, lime, exercises a predominant influence over the rest. It is a fact that all carbonate of iron beds not only contain a notable percentage of carbonate of lime but locally turn into limestone beds; instances may be cited in the coal measures where a bed of iron ore several feet thick becomes in the course of a few hundred yards as thick a bed of limestone comparatively destitute of iron. Now the crystallizing force of carbonate of lime is well known; wherever it can, it forms calcspar: where it cannot, then it forms spheroids carrying with it and arranging the clay and iron in concentric shells. The hydrous silicates (hyallite) do the same.[2]

[2] Dr. C. T. Jackson of Boston has cited in this connection the crystalline sand of Fontainebleau in which grains of silicious sand are forced into the form of calcareous spar by the energetic segregation of the crystallizing carbonate of lime; the inert matter, the sand, being 50 per cent of the whole mass. Dr. Hayes has described a growth of nodules which he has watched and seen "equal to the size of a garden bean, to take place in the course of two or three weeks of wet, spring-time weather. To form a just conception of the conditions, the fact must be kept in view, that the beds containing them are composed of fine silts, and in the case immediately under view, these were arranged in planes of deposition of alternate courses, covered by much finer material, in layers of different thickness; so that the mass was stratified; the coarser layers being very permeable to water. The rounded forms, often strongly resembling organic remains, are found resting between these layers, and a condition necessary to their formation is, *the presence in the layer or rock above them of abundance of carbonate of lime.*"

The force exerted by some salts in their tendency to crystallize is brought into view only when we study their formation, and carbonate of lime is one of the constantly-occurring salts which well illustrates, in a remarkable manner, this power of assuming regular forms. As has been stated, with fifty per cent of its weight of *sand*, it forms regular rhomboids, but the more recent observations of some African travellers, who found their progress impeded by "stone plants," six or eight inches high, formed of aggregates of spear-shaped crystals of sand, cemented by carbonate of lime, show, that this large proportion may be exceeded, while the foreign material is in a somewhat *coarse state.*

In the formation of clay-stones, however, we are to consider the presence of finely-divided matter suspended in, or so mixed with water of infiltration in spring-time, or general saturation from position, that it has nearly a semi-fluid state. A saturated solution of bicarbonate, or more commonly crenate of lime, finds its way into the soft

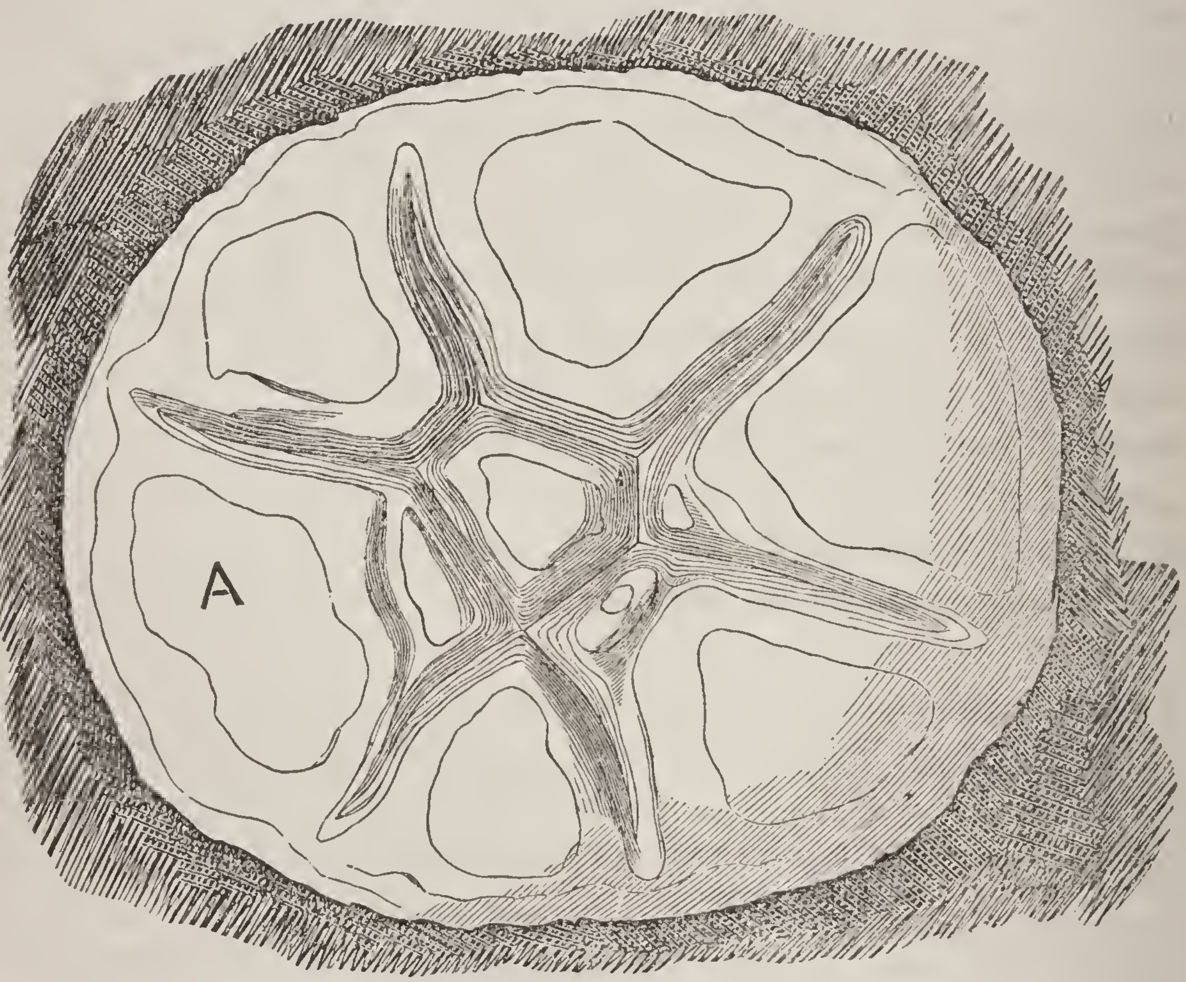
There is often some organic particle or body present to determine the position of the spheres in the body of the rock, but in the vast majority of cases the centre point seems to have been determined by some other occasion, perhaps an accidental and purely mathematical proportion between the weights or sizes of some neighboring atoms. Sometimes, on breaking open a nodule of fine iron ore, a fern frond is revealed, with leaflets spread, and edges gently curled, and every nervure drawn with exquisite exactness. There are whole beds of iron nodules described by western geologists in every one of which resides a shell. Such a one overlies coal No. 9 of the west Kentucky basin, which is wrought at the Saline Company's mines in Illinois, and the nodules contain the *avicula rectalateraria*, *productus muricatus*, and other shells, and even fine pieces of petrified wood. But these nodules are "especially formed of sulphuret of iron and so hard that they can only be broken after they have been roasted in the heaps of burning shales."[3] Now when we remember that the tertiary lignite coal beds convert all their fossils into (not carbonate) but sulphuret of iron, that all the coals of the west are disposed to be abundantly sulphurous and most of them contain sulphuret of iron in nodules, or in plates, either horizontally interstratified with their benches and layers, or vertically inserted between the crystal-joints,—that sulphur has a much stronger affinity

mass, by frost crevices, or channels left by roots, or even air-bubbles, and at these points the concretions commence, when no nuclei of similar chemical composition exist. The finely-divided matter interposes an obstacle to the formation of crystals of carbonate of lime, far greater than an equal amount of coarser foreign matter would do; and we observe, then, the influence of that beautiful law in accordance with which *rounded forms* are produced. In the laboratory similar forms daily occur, where the presence of finely-divided and diffused bodies arrests the formation of crystals, and globular, or curved-surfaced solids are produced; as in the animal frame, the cell-structure causes the dissolved phosphate of lime to take the curvilinear form pertaining to organization. The claystones which are produced under the simple conditions here described, have no concentric structure; a slight conformity to this structure being observed, when a bubble of air, or a vacant space, marks the point of commencing deposition. In other cases, a shell in its calcareous composition offers a preferred nucleus, and as it contributes its lime salt, a concentric arrangement may be noticed in the forms resulting, especially after exposing them to heat. Rounded masses once formed become centres or nuclei of secondary occurring aggregates, one central mass being surrounded by spheres attached; but in all it is easy to read the influence of the tendency of carbonate of lime to crystallize, and the opposition of the finely-divided silt, causing the particles of both to assume forms without straight bounding lines, as the polarizing force of crystallization is arrested in all directions.—*Annual S. D.* 1858.

[3] Lesquereux in Owen, vol. iii.

for iron than carbon has,—and that, nevertheless, in the immediate presence and vicinity of the western coals are found beds of carbonate of iron almost destitute of sulphur,—we see a further reason for doubting the theory that these beds of carbonate of iron were carbonized by effluences from the coal, inasmuch as they would be more likely to be sulphurized.

The study of the nodular masses of the western ore beds will reward itself with some unexpected results. The star-shaped crystallizations which are so common in the nodules of the Kansas coal field are by no means confined to it. The accompanying wood cut A, represents half of a very oblate spheroid, lying

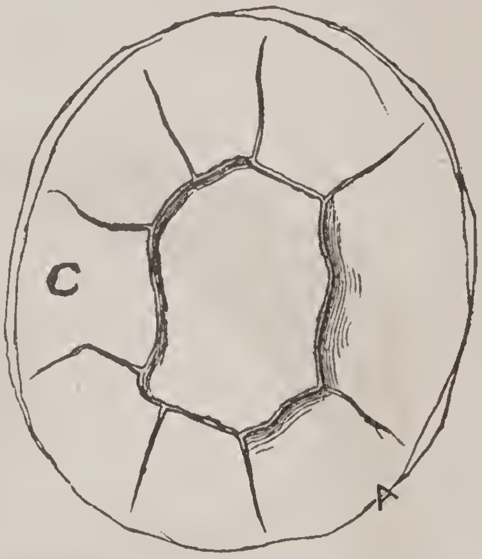


near Station 1741 of Joseph Lesley's B line Lick Fork of Elk Fork of Licking, Morgan county east Kentucky,[4] just above where Casby's coal has been opened, and measuring 4 feet 5 inches in length, by 4 feet 2 inches wide, and about one foot thick; the general appearance, reddish and worn; fracture bluish, showing thin layers of sandy shale which have weathered in the intaglio star in minute terraces as shown in the drawing; the little

[4] Oct. 5, 1858.

valleys forming the star are about 2 inches deep with bevel slopes of 45° and a minute hard ridge elevated along the bottom (as seen in the cross section B), reddish in color and fining to a

point at the head of each vale or ray. A second example (C) not quite so large has the central polygon and radiating lines far less regular, and not channelled but standing out in relief. It is evident that this internal structure has nothing to do with the origin of the nodule, but dates from its contraction (probably while drying) at which time cracks ran through the mass and these were afterwards filled by infiltration. Sulphate of lime has been formed and preserved in this way in the coal measures, from which in the other and more usual forms it is almost wholly absent.



The process of converting these protocarbonate of iron beds into hydrated peroxide of iron seems to have gone off faster or slower, more or less thoroughly, according to circumstances the chief of which were no doubt the porous condition of the superimposed layers of mud and sand. No doubt when the insoluble silicate of lime is an abundant ingredient in the mass, and composed chiefly of carbonate of iron and lime, the degradation and metamorphosis of the bed becomes a work of almost infinite difficulty and duration ; and we see the outcrops of silicious limestones therefore and of silicious carbonate iron ore exposed in cliffs and beds of streams unchanged as when the first excavation of the valleys laid their edges bare to the influences so powerful over other rocks but which they have unconsciously defied. It is only in the case of fossil-bearing masses of limestone that the surface is roughened by the slow extrusion of the minute organisms, the whorls of pleurotomaria, branching corals and the like. How far electrical action has gone on around the

junction lines of these organisms with the menstruum cannot be discerned, but the slight relief in which millions of years have left the forms upon the formless surface show how insoluble the mineral elements must be. In the case of the iron ores it is evident that the process must have attacked the molecules while distributed, and it will be seen how the buhrstone limonite becomes abundant upon the upper face of the great Ferriferous Limestone of the Lower Coal Measures in proportion to the porous, argillaceous, non-silicious condition of the clay-sands over it from which the ore has been swept down and wherein many nodules of carbonate of iron remain to attest to its origin.

The action of Silica in the metamorphosis of iron has been considered *necessary*, by some physicists, to the intermediate steps of the process, whether we regard the change as proceeding from the side of the oxide to that of the carbonate, or reversely from that of the carbonate to that of the oxide. Volger, however, merely gives the possible cycle of changes, introducing it with the following cautious words:

Whether the reverse process be possible or actual in nature,—whether magnetic iron, iron oxyd, iron oxydhydrat, convert into iron oxydulcarbonat,—whether the combination in nature last mentioned comes in this order of sequences or whether *always* first silica, or some other acid, masters the iron and afterwards yields it up to carbonic acid, future investigations can alone determine. That the silicates have very universally to all appearance furnished the material for making the beds of iron oxydulsesquicarbonate,—that when leached out of the atmospheric carbonated waters they occasioned ironspar and ironhydroxyd layers and veins, Bischof has sufficiently shown. Granted the necessity under which an atom of iron lies to advance through its combinations only in the circle,—this circle of destiny may be thus expressed:—

Iron-oxydul[5]-sesquicarbonate

*	-oxydul-silicate -oxyd-silicate	-oxydul-carbonate (=ironspar, nodular iron ore)
	-oxyd-hydrate	-oxyd-hydrate
	-oxyd	-oxyd { amorphous or red-iron-stone
	-oxydul=magnetic iron	-oxydul (=magnetic iron)

Iron (=malleable iron.)

[5] Or Magnetic oxide.

* Perhaps it would be more proper to leave out entirely this reversed side of the circle and connect the sesquicarbonate immediately with the metallic iron, as it will appear probable [in Volger's next pages] that this sesquicarbonate always intermediates the changes expressed on this side.

It has been reported that *magnetic iron ore* was found in the coal measures and wrought in the furnaces.[6] This can only be explained by what Volger says in his Studien on page 265 :—

Blum describes ironspar crystals formed in clay iron-sparstone in the North Bohemia brown coal clays and afterwards converted to magnetic iron. In the same formation occur thick masses of earthy magnetic iron, not originating as it seems immediately from ironspar, but surrounded by red, partly clayey iron oxide. In Bohemia the case is however complicated by the jaspery burnt character of the plastic or porcelain clay, and the origin of these pseudomorphs have been ascribed to volcanic action, even by Bischof.[7] Basalt seems to have to do with the Siegen ironspar, converting it by free access of oxygen into magnetic iron. If the carbonized clays then suffered a violent sort of eremecausis their carbonate of iron might pass into magnetic iron through the intermediate stage of peroxidation. Such in fact has been the process at the outcrops of the carbonate beds, mixed hydrous and anhydrous ores of which become magnetic when roasted for the furnace; the slow procedure of nature being hastened by the necessities of man.

The spathic iron mine in Roxbury Connecticut occurs in a hill 350 feet high, called Mine Hill, composed of mica slate and metamorphic sandstone dipping 25° 30° due northwest. The vertical vein of ore cuts square across this stratification from the base to the summit of the hill, a distance of half a mile; is of regular width, from 6 to 8 feet, and more than half consists of quartz gangue with no other foreign substances except minute portions of the sulphurets of iron, copper (yellow), lead and zinc. The ore itself is solid, cleaving in rhombs, yellow-grey weathering to reddish-brown, 57 to 60 per cent protoxide iron + 34 to 36 carbonic acid + 0.5 to 1.5 manganese, and about as much lime and magnesia. Its brilliant and unusual appearance among the well known ores of iron led to large expenditures to work it as a silver ore by Hurlbut and Hawley about 1750, and by a second company the Bronson brothers about 1764, who sunk a shaft 125 feet deep under the directions of a German goldsmith, a charlatan named Feuchter, who kept alive the hopes of his employers by producing silver from his crucibles. Even the failure of the company only changed the delusion and the overseer was suspected of having transported the bulk of the silver to his native land. A New York company leased the mine for 42 years, stripped the outcrop half way down the slope and put in a tunnel 115 feet to strike the vein, on which they then drove 33 feet further. Another company formed in Goshen took up then the enterprise and reopened the diggings at the summit until the entire property of several of the members was dissipated. Asahel Bacon a wealthy neighbor then tried it as an iron mine and considerable quantities were sent to the Kent furnace to mix with brown hematite; it made a tough and excellent metal. Finally a furnace was erected near the mine to smelt the ore alone but was abandoned; but David J. Stiles caused some of its pig metal to be converted into excellent steel, which raised the reputation of the ore on another and better basis. The old shaft and side drain were again cleaned out by a New York company which claimed to possess the old mining title, but the title fell into the hands of lawyers and nothing further was accomplished but the revival of a general belief in the existence of a genuine silver vein two feet thick traversing the entire

[6] Bulletin Amer. Iron Assoc., Charcoal Furnaces, W. Pennsylvania.
[7] Geologie, ii. p. 583.

extent of the iron ore, *at the bottom of the shaft.* The German steel of Austria is made almost exclusively from ore of this kind.[6]

The ore of the Black Slates of VIII occurs in **Lower Devonian** strata, the Cadent Older Black Slate of Rogers. It appears on both sides of the great Appalachian central region, both in middle Pennsylvania and in middle Kentucky. The formation in Pennsylvania as described by Dr. Henderson consists of three members: the uppermost

1. Black fissile carbonaceous slate, 180 feet.
2. Greenish clay limestone and shale, 20 feet.
3. Buff and grey limy shales, 25 feet.

All three contain fossil shells, the uppermost and undermost containing small shells. The thicknesses given are from measurements at Half Fall mountain in middle Pennsylvania. At the Susquehanna above Harrisburg they seem to be thinner, the limestone having disappeared on its way east. The iron ore lies over the limestone near the bottom of the black coal slates, and is a grey or lead-colored protocarbonate, weathering along the outcrop (and sometimes in the body of the bed) into the common porous earthy brown hematite. It is in all respects a fac-simile of the carbonates of the coal measures; and is in fact a prophecy of them,—as the black slate in which it lies is of the black slates of the coal measures. We are at the horizon, where the unsuccessful first attempt to establish a system of coal measures was made. A second less unsuccessful attempt was made at the upper part of the Devonian pile, towards the close of the Devonian era, in the beginning of the deposit of the XI red shale, when beds of workable coal were actually deposited over small areas, but the level of the then surface was still too uneven to admit of a continental growth of vegetation such as resulted in the great coal measures. In the early Devonian times of the black slates of VIII still smaller portions of the surface were in a fit condition to make coal, while the waters were nevertheless charged with carbonaceous stuff, we know not how, which blackened all their mud, and here and there was packed pure and close enough to become in time apparent coal beds some few inches thick. This is the formation which has done so much

[4] Shepard's Report of the Geol. Sur. of Conn. quoted in Cothren's History of Ancient Woodbury, 1854.

New York.

mischief, deceived so many farmers, and swamped the capital of so many credulous speculators led on by ignorant and designing men calling themselves geologists to dig for coal outside the limits of the true coal regions.

For long stretches of the outcrop lines, zigzag and parallel, of this formation no iron ore is seen; just as in the Coal Measures whole counties and regions have no ore beds at the geological levels where in neighboring districts ore abounds.

In **New York** the ore of the Napanock furnace (A 15 on the Rondout river in Dutchess county) mined a third of a mile south of the stack and the same distance from the Delaware and Hudson canal, is a peculiar, solid, dark-grey, homogeneous ore, containing small geodes of sulphuret of iron and lenticular fragments of metamorphosed clay-slate and occasional markings as if of fossils, but not organic, and is supposed by Hodge to be of Devonian age, perhaps this ore of the lower part of Formation VIII. It is used mixed with 25 per cent its own weight of magnetic ore.[9]

In **Pennsylvania**, at old Juniata furnace (E 142) the ore of VIII is a bed of brown hematite, cellular and earthy, from 8 to 10 feet thick, and pitching 45° to the northwest between the black slates, a few feet above the Limestone, and about 100 feet above the Oriskany Sandstone VII. It is the only place along this range of outcrop where the ore is profitably dug, although the limestone is frequently exposed and the place for the ore can never be mistaken. But along the northwest base of Mohanoy ridge, south of Bloomfield, it has been mined for old Juniata and Perry furnaces along a line of three or four miles, standing vertical and about 80 feet from the top of the Oriskany Sandstone VII. No ore appears southeast of Perry furnace. It reappears abundantly at old Oak grove furnace 5 feet thick and runs along the Blue mountain eastward four miles towards Sterritt's Gap, lying everywhere about 50 feet above the Oriskany Sandstone VII.[1] As all three of the furnaces have been abandoned while the mountains must remain timberland, the ore of VIII is not recommended by its treatment in this region.

In Perry and Mifflin counties Pennsylvania there is a bed of ore immediately above the Limestone of VIII. The order of rocks in Perry is as follows: descending—

[9] Bulletin American Iron Association, Notes p. 66, 1857.
[1] Dr. Henderson in Annual Report, , and Final Report, p. 362.

VIII
- Chemung group of New York.
- Portage group of New York (Vergent)—gone.
- Genesee (Cadent upper) black slate—gone.
- (Cadent older black slates)
  - Black slate with small fossils 180 feet.
  - Iron ore.
  - Greenish clay limestone, shales, with *atrypa limitaris*, etc. — 20 feet.
  - Buff, grey, calc. shales, with minute fossils. — 25 feet.

VII Oriskany (Meridian) Sandstone.

The whole group thins southeastward; the Portage and Genesee rocks come in above thickening northwestward; the clay limestone "preserves its aspect and thickness with little change over the whole country, though it does not exist at the Susquehanna in the base of the Kittatinny mountain."[2] Immediately above it lies the ore, a lead-colored protocarbonate of iron, weathering to a dark-brown cellular hydrated oxide, and thickening towards the southwest.[3] It was mined at Juniata furnace 100 feet above VII. Along the northwest base of Mahonoy ridge it is continuous for three or four miles and was used also at Perry furnace.

In Huntingdon and Bedford counties the same ore is seen in lumps upon the surface along the outcrop of black slates and superior red shales in the bottom of VIII, along Woodcock valley, west of Broad Top and elsewhere.—In Juniata and Union counties it is not known as an ore, but in the southeast of Huntingdon it is placed and constituted precisely as in Little Cove. In Pfout's valley towards the Susquehanna the shales above the ore are capped by green coarse massive sandstones growing soft brown and very massive towards the top full of large fossils. Dr. Henderson shows that this sandstone group forming high ridges is a local feature of the eastern end of his district. These black slates have been explored for *coal* (of course in vain) much more than for iron ore. The ore was once opened in Shade Gap, two to four feet thick, a blue carbonate like that of the coal measures. It passes into Fulton county southeast of Littleton, distant 100 yards from the foot of the grey sandstone ridge

[2] Final Report, p. 355. [3] Final Report, p. 390.

Pennsylvania.

of VIII.[4] It occurs also in Blacklog mountain. McKinley describes it[5] in the Lewistown valley as a noble deposit from 3 or 4 to 10 or 15 feet thick from 50 to 100 feet above the top of VI (Oriskany sandstone), sometimes in the form of a heavy square-jointed rock, in layers a few inches thick, not effervescing with acids, but growing red and magnetic in roasting. At the surface it is a soft brown hematite or clay oxide, sometimes cubic and cellular, with glazed and iridescent walls to the cells half an inch thick, the cells empty, or full of water or full of clay. At Selinsgrove on the Susquehanna he calls the black slates 660 feet thick. In Sideling hill on the Potomac Mr. Rogers calls them 590. At Selinsgrove two sets of limestones are embraced by the black fissile *pyritous* slates, the lower being 70 feet thick and lying 45 feet above the bottom. On the Potomac the lower 130 feet consists of black slate and ash-colored shales, then 200 of black slate, then 30 feet of calcareous shales and a few clay limestones, and lastly on top 240 feet of black slate. Between these two points at Lewistown and Waynesburg the lower Selinsgrove limestone 10 feet thick is seen dying out within from 10 to 30 feet of the bottom, and above it lie the sulphurous slates, and the carbonate iron ore is coming in. It was used once in the old furnace which stood on the site of Roush's forge, but the ore was neither rich nor abundant. A sulphureted-hydrogen spring with an odor perceptible for 100 yards, here shows how pyritous the slates are and suggests the formation of the iron ore.[6]

As we proceed towards the Potomac the ore banks grow productive. They are situated on small runs where the change to peroxide has been easy. Brookland furnace formerly got ore north of Atkinson's mill in Ferguson's valley, but it did not make good iron. Hope furnace also opened a neighboring bank. It is probably abundant along the narrow belt leading into Green-Briar valley. Creswell's bank $2\frac{1}{2}$ miles northeast of Waynesburg was opened in the same synclinal which passes a few hundred yards southeast of Hope furnace. Morrison's ore bank northwest of the southwest end of Prater's ridge has been very valuable. Mevey's and Bell's banks near Newton Hamilton at the north end of Owen's ridge along Blue Ridge

[4] Final Report, p. 394. [5] pp. 399, 400. [6] Final Report, p. 410.

mountain are on another belt which is prolonged past Shirleysburg and Orbisonia. Several ore banks mark the synclinal basin of Negro valley prolonged southwestward, and have supplied several furnaces, most of the openings being on the northwest dips. Chester furnace is 2¾ miles northwest of Orbisonia, across this basin, and its ore banks along Chestnut ridge showed from 3 to 6 feet of ore, dipping 30° southeast. In great Aughwick valley very little of this ore has ever been discovered; nor any in Pigeon cove district. In Little cove in Franklin county near the Maryland State line the Warren furnace banks show the ore 100 feet above the sandstone of VII.* Three miles from Bedford, at S. Wyman's, ore shells and bombs appear along the outcrop of dark fetid clay limestone; at Steele's 3 miles from Savage's; at General Piper's, whence it was hauled to Hopewell furnace; and at Renard's 3 miles further south, all on the same line.[7]

Along the last outcrop of these rocks before they plunge beneath the Alleghany mountain western county, that is along the northern foot of the Bald Eagle, Dunning's and Will's mountain from Muncy on the West Branch Susquehanna to Cumberland on the Potomac, they may be represented by Rogers's section at the latter place[8] as follows:

IX	(Ponent) red sandstones, etc.	
VIII	(Vergent) shales . . .	2,100 feet.
	(Vergent flags	1,600 "
	Upper black slate (Cadent) .	700 "
	Lower black slate (Cadent) .	400 +
VII	(Meridian) (Oriskany) sandstone	150 —
	(Meridian) slate . . .	unknown.
VI	Limestone (Premeridian) . .	200 ?
	Limestone (Scalent) . . .	250
V	Variegated grey marles (Scalent)	thick.
	Variegated Red shales (Surgent)	

The lower black slates are everywhere alike, and recognizable by the *Orthis limitaris.* The lower division of the mass contains no clay-and-iron-limestones at the Muncy Williamsport end, but only cakes and nodules of blue limestone, which as we ascend the Susquehanna and Bald Eagle creek increase in number and in size, while the whole mass of slates *decreases* from

* Final Report, p. 429. [7] Final Report, p. 527. [8] Fig. 108, p. 541, Final Report.

600 feet at Muncy to 350 and 400 at Frankstown and Cumberland.

Pennsylvania.

The upper black slates, finely micaceous (?) and with a minute arrow-head leaf-like fossil (graptolite?) among the rest *increases* in thickness in that direction from 250 feet in the Muncy hills to 700 at Cumberland.

Between them lie the olive shales of VIII (cadent), hard blue, *calcareous* and sandy at the northeast end, with *microdon bella-striata*, *delthyris mucronata*, *fucoides velum*, etc. and much more of a clay limestone at Lockhaven, where it contains small balls of iron pyrites. At Frankstown it is 400 feet thick, but soon dwindles away and disappears before reaching the Potomac, allowing both the black slates to come together.

At Muncy the black slates of VIII are covered with an efflorescence of iron and alum and include lime layers. Near Hughville these are full of crystals of sulphuret of iron. At New Liberty near Lockhaven the blue pyritous lime layers lie under, at Jersey shore over the black slate. At Lockhaven they contain nodules of pyrites. At Plunkett's creek they approximate a pure limestone.

Baker's ore bank near Altoona, opposite Blair furnace; see page 586 above.

On Dunning's creek west of Bedford, the black slates form an *alum bank* (like that in the coal measures at Blairsville) with nodules of limestone 4 feet thick.

In **Little cove** (the rim of which consists of Upper Silurian No. IV, and the centre of Devonian No. VIII), the Warren furnace ore beds occur near the centre, in the lowest layers of the No. VIII slate, and yield the same grey carbonate as in Huntingdon and Bedford counties.[9]

In **Virginia,** ore is alluded to by the State geologist as existing at this horizon, but nothing is known of its appearance as a mining belt until we cross the coal region and find its western outcrop through **Ohio** and **Kentucky**. Here it originates bog-ores which were wrought at one time north of the Ohio river, in Adams county Ohio, by furnaces now thirty years abandoned. But south of the Ohio river it obtains a local notoriety as an

[9] Dr. Henderson in Final Report, p. 262.

iron ore formation, in Bullit and Nelson counties, Kentucky, where it is smelted, or has been, by Belmont, Saltriver and Nelson furnaces (K 546, 547, 548), as described in Owen's second volume of the Kentucky Survey, p. 93, etc. Here in the "Knobs of Bullett" lie beds of kidney and sheet ore in a mass of grey and ash-colored shales overlying the black slate of VIII, and ranging through the southeast portion of the "knobbly region" along the waters of Cane river, southeastwardly into Nelson county. The section given is as follows:

Knob freestone, locally inclosing ore, see analysis No. 489.	
Grey shales with kidney and sheet ore, see analyses No. 488, 493	
Black shelly shale, locally inclosing limestone, . .	15 feet.
Black shelly shale, greyer and more leafy, . . .	60 feet;

and these knob ores, like the carbonates of the coal measures, vary in thickness from 3 to 8 inches, the balls of kidney ore being disseminated over a pavement of sheet ore. This fact alone, repeating itself in so many cases, is sufficient to convince us that the precipitation of the carbonate of iron was an original chemico-mechanical deposition, accomplished, through a mass of wet consolidating rock, rapidly enough at first to make the single bottom layer homogeneous, and more and more slowly afterwards (as the rock acquired greater consistency through time, its own chemical arrangements and increasing weight of new formations to its top), until all downward movement of the carbonate of iron became impossible and localized adcentric movements alone continued; these finally stopping, to allow the vein crystallization to proceed, as cracks developed themselves either in the rock layers or in the plate or in the nodules of the ore. Considerable bodies of the ore are dug from the precipitous bluffs of the river, in strippings from 20 to 25 feet wide, and delivered at Belfont furnace for $1 50 to $2 00 per ton. The iron is in request for nails. The ore analyzes as follows: Spec. grav. 3.446; iron 32.62; magnesia 11.75; lime 6.28; manganese 1.32; phosphoric acid 0.71; sulphur 0.29; potash 0.75; silica, etc. 11.18. The *flux* got near the furnace contains also 13.22 of magnesia and 1.51 of sulphur. (Dr. Peter's Report.)

At Nelson furnace the ore can be delivered for $0 75. In Salt Spring Hollow this ore makes a solid 12–16 inch pavement, 28 feet above the top of the black slates of VIII. Higher up

Kentucky.

just under the knob freestone a poorer sheet ore can be got. The flux (magnesian limestone) comes from between Beech fork and the furnace. Hearthstones come from Hart county. The knob ore is probably workable from southeast Bullit county into Larue. Beech prevails with some oak, hickory, poplar, walnut and cedars. (Owen's Report, iii. 95.)

In **Eastern Kentucky Bath county** the knob ore of VIII is observed in the grey shale over the black slate on Mud creek waters, the quantity of ore increasing gradually southward. Five beds of block and kidney exist on Salt lick and Clear creek. Plenty of ore here to run a furnace and make good soft iron.

In **Rowan county** where the black slate is of great thickness (over a hundred feet), and the ash-colored shale is poorly developed, the kidney ore is not in any abundance.

In **Powell county** on the contrary the ash shales are in great force, 140 feet thick, with some disseminated carbonate of iron. Between Stanton and the forge is seen the following section:—Dark shale—ore band of carbonate of iron 3 to 6 inches—shale etc. 18 inches—ore band 2 to 4 inches—dark shale etc. 8 to ten feet—ore band 2 to 4 inches—dark shale etc. 4 feet—small kidney ore—shale etc. 3 feet—ore band 2 to 6 inches—dark shales 3 to 4 feet.

In **Estill county** the ash shales contain considerable beds of ore, lying some 400 feet below the California ore banks of XI, in a section like the following:—White pebbly sandstones (No. XII)—coal shales 10 to 15 feet—ferruginous shale—rough ore—shale—lower main ore (No. XI)—upper beds of white and buff sub-carboniferous limestone—sandstone—grey middle beds of limestone—sandstone 110 feet—white lower beds of limestone 95 feet—knob freestone 200 feet—ash shales and knob ore 140 feet—black shale (Devonian No. VIII) 100 feet below water level. Frequent indications of these ores of VIII are seen between Hardwick's creek and the forge, especially 3 miles from the latter. On the Estill and Madison line the knob sandstone curiously disappears, although it is a formation 400 feet thick on the other side of the Kentucky river. At Knob lick the summits are capped with sub-carboniferous limestone, while the creeks flow over black slate; the ore of the intermediate ash shales are represented only by *spherical segregations of carbonate of lime and sulphuret of iron* in the

black slate, with small quantities of sulphuret of zinc and possibly a little lead. Red lick shows the ash shales on the black slates again, and they contain on Station Camp creek considerable quantities of the ore.

In **Lincoln county** the bed of Flat lick is black slate over which are the ash shales with large quantities of disseminated carbonate of iron. At the head of the lick *the black slates seem to have been on fire and roasted the ore over them to a dark red oxide for the furnace.* The Flatlick is a depression of many acres, and around it "the shales show four or five distinct bands of carbonate of iron interstratified in the shale in a vertical height of 5 to 6 feet which will average 6 inches in thickness." The ore contains 3.77 of iron, requires little limestone, contains only 0.21 sulphur, and tons of it lie strewed about the place, which is well worthy of the attention of the iron manufacturer.

In **Boyle county** at its southern edge, on Dick's river, Flat lick is repeated in Knob lick, which however only cuts down to the top of the Devonian black slates. Much ore is disseminated here also through the ash shales at 40 and at 90 feet above the black slate, but not so abundantly as in Lincoln.

Hence southwestward through **Casey, Russell, Cumberland and Monroe counties** to the Tennessee line, a great fault or dislocation carries forward the outcrop of Devonian black slates and ash shales in a straight line, but no beds of iron ore are described as characterizing the latter; but in its place seem to have come in beds of chert and sandy lime layers, especially where the shales and slates join in Monroe county. There is in Monroe county an immense mass of shaly rocks which appear to be wholly wanting in Cumberland and Russell, and in this new state of things the iron ore disappears. Nor is ore mentioned in these shales in Taylor and Larue.[1]

In **Northern Pennsylvania** Tioga and Bradford counties the Lower Devonian olive slates of VIII contain a fossiliferous iron ore on which the Mansfield furnace is now running. It is in the range of two beds of limestone 100 feet apart and the uppermost or thinest 50 feet below the top of the Vergent rocks of Rogers. The other is 10 to 15 feet thick upon the Susque-

[1] Owen's Kentucky Reports.

N. Pennsylvania.

hanna, 4 at the mouth of Carbon creek, and at Wellsborough there are several strata. It is full of fossils, which where the limestone is absent have been turned to or coated with the ore. It has been long opened at Roseville on Mill creek as a red sandy soft stone, blood red when scratched, in flags of two or three inches thickness, making in all *two feet*, over 3 feet of red sandstone, under which are many large balls of sandy ore.[2] In many of the surrounding hills the ore is soft enough to be used for red chalk. It is mined 4 miles west of the Mansfield furnace. South of Mansfield one mile it is opened by Mr. Boxby for paint, 12 to 15 inches thick under 6 feet of red shale under six feet of red sandstone. Some of it is oölitic (fish-roe) or seedy like the fossil ore of V. This ore probably appears again on Troup's creek at the State line, half a mile above the saw-mill. The *red band* of VIII which the author traced westward throughout the northern counties towards the Clarion river in 1841 is in the position of this ore and Mr. Rogers is disposed to identify them.[3]

On Schroeder's branch of Towanda creek in Bradford county a red fossiliferous ore bed 2 feet thick with another red fossiliferous iron sandstone (like that of Montour's Ridge), 8 feet under it, hold somewhat the same position.[4]

In **Northern Pennsylvania** an ore in the Devonian red and grey beds (Vergent, Chemung and Portage) VIII and IX appears on Larrey's and Lycoming creeks, where they break out from the Alleghany mountain north of Williamsport Lycoming county Pennsylvania. On Lycoming creek 7 miles above its mouth it is from 1½ to 2 feet thick, under olive slates, and in the neighborhood of two layers (3 feet each) of coarse, grey-red, impure limestone, a confused mass of shells; over which extremely fossiliferous olive shales; then thick and variegated shales and slates. On Larrey's creek north of Jersey shore, between Knox's Mill and the forge are the variegated shales and sandstones, high over which are the deserted ore drifts of the Farrandsville Furnace Company. Two miles west of Larrey's creek in Canoe run the ore is 3 feet thick, divided in the middle by 2 or 3

[2] Mr Rogers's text and diagram on page 311 are exactly the reverse of each other, owing probably to the construction of the diagram from an ascending series of rocks written down the page.

[3] Fin. Rep. p. 312.

[4] Fin. Rep. p. 309.

inches of slate. In another opening, 6 inches of slate separate a lower 18-inch and an upper 6-inch bed of the ore, which is everywhere a compact bluish-brown plate, under olive shales. Two miles north of Jersey-shore the shales are fossiliferous and the ore 18 inches thick. It continues up the valley of the Susquehanna and appears at Davis's one mile east of main Chatham run, half a mile distant from the base of the Alleghany mountain. Up Beech creek (west of Lockhaven) 17 miles the ore has been again recognized.

In the Third or Bennett's Branch Bituminous Coal Basin of the Upper Susquehanna, where the grey sands of X come up above the water level at least 200 feet, there are many little yellowish balls of excellent iron ore associated with an indifferent shelly limestone, 4 feet thick, full of fossil shells, and remains of one or two fishes.[5]

In **Central Pennsylvania** Huntingdon county, iron ore at the base of the (Umbral) red shales of XI has been mined and used for Trough creek and Hopewell furnaces. It is a brown jaspery ball ore in some of its layers, and a lead-colored heavy manganesian ore in others. In the tunnel in Hopewell gap through Terrace mountain a bed from 2 to 3 feet thick of brown compact jaspery good ore and yellow slaty ore stands between steep strata of red shale (XI) above and coarse yellowish sandstone (X) below. Thin layers of sandy ore come in among the red shale beds and the sandstone floor is full of iron. The bed is evidently an original deposit from the red shale upon the face of the older white sandstone sea bottom. In encircles the Broad Top mountain with its group of slender parallel coal basins, and large masses of hematized outcrop ore cover the slope where the dip is gentle. Manganese accompanies the iron where it is opened in Ground Hog valley. Above the iron ore appears a bed of massive, tough and fetid limestone several feet thick, which has probably had some hand in the chemical precipitation of the iron ore bed under it. It is sometimes red and ferruginous itself and is covered sometimes by many feet of red calcareous shale, containing bitter spar. The limestone is almost destitute of fossils.[6]

[5] Hodge in Fifth Annual Report of Geol. Sur. of Penn., p. 60. [6] Final Report, p. 530.

ANALYSES OF IRON ORES OF THE UMBRAL RED SHALES OF PENNSYLVANIA. (NO. XI.)

Localities.	Carbonate of Iron.	Peroxide of Iron.	Oxide of Manganese.	Carbonate of Lime.	Carbonate of Magnesia.	Silica and Insoluble Matter.	Alumina.	Carbonaceous Matter, etc.	Water.	Metallic Iron in 100 Parts.	Description of the Ores.
Savages's Mines, Trough Creek, Huntingdon Co.,	..	88.09	..	..	..	a trace	..	..	11.00	69.93	Reddish-brown, compact and jaspery.
Hopewell Furnace (Old Bank), Trough Creek,	..	60.00	a trace	0.40	..	32.10	2.50	..	3.50	42.00	Red and brown, nodular.
Hopewell Furnace, Terrace Mount Mine,	..	84.00	a trace	..	..	2.30	a trace	..	13.50	58.80	Dull chocolate-brown, compact.
Ralston, Lycoming Co.,	65.00	..	..	0.72	..	28.80	1.00	..	4.28	32.06	Ash-grey, spathose.
Astonville. Frozen Mine, Lycoming County,	68.00	..	..	0.60	..	28.70	0.80	..	1.50	32.80	Pinkish-yellow, velvet-like, minutely crystalline.
Farrandsville (Lower Red Shale),	..	68.40	..	a trace	..	25.60	3.60	..	2.00	47.88	Purplish-red, compact, nodular, sub-crystalline.
Johnson Hill, Blossburg,	29.84	..	a trace	..	..	66.80	0.50	..	2.56	14.42	Light-grey, pinkish, spathose.
Bennett's Branch, $1\frac{1}{2}$ miles above Warner's, Clearfield County,	82.20	6.50	..	..	..	6.65	1.00	..	3.40	44.22	Dull-grey, compact.
Bennett's Branch, same locality,	63.80	..	1.00	..	..	30.90	0.75	..	2.75	30.28	Grey, light, compact, and coarser than the above.
S.E. of Blairsville, Indiana Co..	37.80	..	..	5.50	7.50	37.80	7.60	..	3.50	18.27	Mottled-red and green, nodular, somewhat spathose.
Hill's, W. side of Chestnut Ridge, Indiana County,	..	51.25	a trace	2.00	..	36.50	5.96	..	4.00	35.87	Cinnamon-brown, nodular.
Garey's Mine, Fayette Co.,	84.14	2.78	a trace	3.00	..	..	0.75	..	5.00	40.62	Dove-color, externally brown, nodular, close-grained.
Garey's Mine, same locality,	35.50	..	..	2.50	1.35	15.55	2.80	..	2.00	38.22	Greyish-blue, kidney-formed, close-grained.
Chestnut Ridge, Pennsylvania Canal, Westmoreland Co.,	..	61.50	..	a trace	a trace	31.44	1.25	..	5.20	41.05	Purplish-brown and greenish, jaspery.
Hare's Valley, Huntingdon Co.,	..	97.54	..	..	..	3.12	0.18	..	..	67.63	Purplish-red, massive, micaceous, unctuous (a surface specimen.)

The Umbral red shale of the bituminous coal region is accompanied throughout nearly its entire outcrop along the Alleghany mountain, and towards the northwest, by a very peculiar variety of iron ore, which, in certain localities already described, is destined to become of much economical importance. This ore occurs high in the formation, usually not more than a few feet below the bottom of the Seral conglomerate. It is the grey and mottled carbonate of iron described in the chapter upon the Umbral strata. The ore is of somewhat various external features, but its most prevailing character is that of irregular knotty nodules of a mottled red and whitish or grey color. These lumps, which are usually imbedded in a soft reddish shale, are often, especially near the outcrop of the stratum, coated with a brown crust of the peroxide of iron. On Lycoming creek, the purer specimens of the ore, consisting principally of the crystalline carbonate of iron and silica, are internally of a pinkish-yellow color, with a velvet-like aspect. In other districts, as that of Tioga river, near Blossburg, the ore is in regular continuous layers, certain parts of which are mottled, and have almost an oölitic structure. It is only in certain local tracts of country that this interesting ore is rich enough in iron, and thick enough to be of value to the manufacturer of iron; but where it can be used, the metal procured from it is of remarkable excellence. The chemical nature and geological relations of this ore are very similar to those of the carbonate of iron of the coal strata, and the conditions under which it originated were obviously very nearly identical with those which produced that variety. Beside the nodular crystallline carbonate now described, the Umbral shales contain, especially in their southwest outcrops, as in Somerset and Fayette counties, a species of ore identical with the ordinary compact or earthy carbonate of the coal measures. This latter kind belongs to a small subordinate group of coal-bearing rocks, which, in the districts mentioned, underlie the true Seral conglomerate, or constitute its lowest member, indicating a gradual transition from the Umbral series.[7]

The ore of XI is mined into in the greenish buff shales under the Conglomerate on Meadow run branch of Roaring brook, south side of the Lackawanna valley, six miles east of Pittston. It dips northwest 10° to 20°, between sandstone rocks, and varies from 1½ to 2 feet and even 3 and 4 feet in the upper drifts. Large nodules are found imbedded in the fire-clay roof, one foot thick. An impure limestone is found not far off.[8] The outcrop has been opened for a mile upon the lands of the Lackawanna Iron and Coal Company, but cannot be found in the upper valley of Spring brook nor at Cobb's gap of Roaring brook. At the mines the ore lies imbedded in 6 feet of fire-clay (containing the usual *stigmaria*) in two layers, the lower one a continuous band some 18 inches and the upper a layer of flat balls 12 inches thick. The buff, green sandy shales below, rest on grey compact sandstone, "the upper bed" Mr. Rogers

[7] H. D. Rogers's Final Report, vol. ii. chap. vii. p. 734.

[8] Final Report, vol. ii. page 405. On page 357 another and lower position is assigned this ore, viz. "just above the upper layers of the Vespertine sandstone (X), or among the lowest shales and fire-clay beds of the Umbral series" (XI).

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thinks "of the great Vespertine or Lowest carboniferous series." Over the ore bed are 30 feet of solid fine grey, argillaceous shaly sandstone, in the middle of which runs a foot of fire-clay with scattered ore balls. Over this are 30 feet of red and yellow shale.[9]

The ore near the outcrop is a mottled dark green and red subcrystalline mixture of the carbonates of iron and lime with the peroxide and protoxide of iron, containing besides alumina and some silica. It is readily fusible and holding a small amount of carbonate of lime assists in fluxing other ores. Its percentage varies between 25 and 45.[1]

Mr. Rogers expresses the opinion that the ore of XI at Scranton, in Pennsylvania, is "a concretionary deposit, collected from the imbedding fire-clay and overlying strata at their outcrop.[2] The oxide and carbonate of iron of which it is composed, have been primarily diffused through these rocks, in part perhaps, under the form of sulphuret of iron, and subsequently gathered thus into sheets and layers of balls, by infiltration of the rain and other surface waters. In confirmation of this view of the origin of the ore, it appears that the deposit grows less rich in iron wherever it is followed far into the hill, or is covered with tight overlying strata [so] as to have experienced a less than ordinary share of percolation from the surface. In these positions the ore is little else than a fire-clay with a merely greater than usual impregnation of the oxide of iron." Two inconsistent ideas are here presented as one; for the lack of ore must be due either to a lack of surface water (when the upper rock is too tight) or to a lack of iron in the upper rock. But if the latter be the cause, then the distribution of the segregated ore has nothing to do with the present surface or its outcrops; beds of ore will underlie the Lackawanna coalfield anywhere, wherever the Upper rock (to the ore) has been sufficiently ferruginous. But Mr. Rogers is wrong again to ascribe so great a

[9] Mr. Rogers also gives a vertical section which does not agree with this description, perhaps because taken at another locality. It reads *downwards* :—Conglom. sandstone 130 feet; ore balls; conglom. sand. 70 feet; false bedded sandstone 40 feet; ore ball stratum 2 to 3; sandstone 30; shaly sandstone 30; sandstone 15 to 25; ore? sand 10; fire-clay 6 including two beds of ore 1 foot each; shale 10 feet, etc. etc.

[1] Rogers, ii. p. 358.

[2] Considering the extent of the ores of XI this expression "at their outcrop" is incomprehensible.

part of the action to surface rain water. The original sea-water-soaked condition of the sub-carboniferous formations, previous to and after its emergence is a much worthier, because more mighty agency. Hence again the ore bed can have no real, but only here a local and deceptive relation to the surface outcrop.

In **Kingston hollow,** a gorge through the conglomerate **north of Wilksbarre** the ore of XI is just reported[6] as opened in two beds 6 feet apart the upper one 37 and the lower one 47 inches thick, solid ore, the roof being a shale with walls of ore, and the interval and the floor solid sandstone; the distance on a level below the lowest coal bed (above the conglomerate) is about 1200 feet with a dip of 14°, making a distance of 200 feet vertical. If this be a fair estimate of the size of the deposit, it is perhaps the finest exhibition of it yet known. To the geologist it is interesting as the analogue of the Lockhaven (Farrandsville) and Hopewell (Huntingdon, Broad Top lower) ore; for it is said to lie under 60 feet of calcareous sandstone, under red-shale, under another bed of sandrock, under another red shale, under the conglomerate.[7]

The upper ore of XI occurs under similar aspects beneath the conglomerate around Broad Top, and has just been opened (Feb. 23, 1859) on Sandy run, half a mile above Hopewell. Huntingdon county Pennsylvania, in fire-clay, and in two layers of flattened balls in all 2½ feet thick. It is quarried at Ralston in Lycoming county, at Blossburg in Lycoming county, in Somerset, Fayette and Westmoreland counties Pennsylvania and the neighboring counties of northwest Virginia, and along the whole western border of the coal area from northeastern Ohio into middle Tennessee. To talk of its slate being a segregation *at the outcrop* is simply absurd. The deposit of fire-clay which accompanies this ore is as remarkable as any other feature of the formation. Is *it* also a segregation at the surface? Of course not. Like the fire-clays beneath the beds of coal, which often contain balls of

[6] Mr. Lippencott of Wilksbarre; and letter of Wm. Brisbane, March 1859.

[7] In the north edge of the Wyoming anthracite coal basin, 500 or 600 feet below the conglomerate XII, in Hertzoff's hollow, north of Kingston, two beds of black, heavy, sandy ore, in fact a fine conglomerate cemented with an iron paste, the upper 2 feet the lower 4 feet thick occur, with 5 feet of hard rock between them, and olive ferruginous shales above and below them. Some of the ore has been taken to Danville and used.—*Final Report* i. p. 407.

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ore, this fire-clay was a great sub-continental deposit or coëtaneous group of area-formations, containing its own plant roots and its own contemporaneous infusion of iron ore, such as informs the bog beds of the present day. In and upon this fire-clay of XI, in many parts of the continent, the plants, as Lesquereux describes, grew, under conditions favorable enough to make a coal bed, or to begin one, for the process in a thousand places was arrested before it was complete. We therefore see over the Broad Top ore of XI a stratum of clay and flaggy sand 18 inches thick, and then traces of coal, upon which lies the great grey sand rock of XII.

At Blossburg we have the following section under the conglomerate (XII) which is here 20 feet thick.

	Feet.
Conglomerate (XII)	20
Black slate (answering in place of a coal bed)	2
Grey ore, in balls and plates	1
Fire-clay containing balls of ore Red shale, with a six-inch stratum of balls Blue shale	14
Nut ore in clay (mined in a 5-foot gangway)	2
One or two beds of fire-clay	4
Slate	12
Massive ball ore, three plates, 8, $2\frac{1}{2}$, 5 in. (mined)	2
Blue slate	10
Ore in two plates, averaging 4 inches each (mined)	5
Blue slate, the remainder of the 60 feet down from XII.	
Red shale of XI; with	
Ore near or upon its uppermost layer. (June 5, 1857.)	

In Rogers's Final Report[6] he inserts Humphrey's and Evans' section, the lower part of which reads thus descending:—Pea-conglomerate (XII) 7 feet, white sandstone 20,—shales with lean oölitic **ore** $1\frac{1}{2}$, **ore** $1\frac{1}{2}$ **to** 2, red and mottled shale 6, **ore** $\frac{1}{2}$, shale 10, shale with coarse nodular **ore** 2, clay-sand and shale 20, shale (with $1\frac{1}{2}$ **of grey ore**) 4, slate with 7 inches ore 6, slate 6, dark brown, mica sand, 20, red and green shale 5, grey-green sand 150, to level of railway, red shale 4 to 5, sandstone (X) with

[6] Vol. ii. page 520.

a lime-bed thirty feet above the bottom 150, red shale and marl 30, green flag sands.—The long balls of ore in the shale under XII lie close together and form half the stratum; they consist of concentric crusts peeling off on exposure; under them lies a nearly solid bed of heavy yellow-grey ore 6 inches thick of a true oölitic structure.

These ore beds seem more numerous here than at other places only because the Blossburg strata have been very thoroughly explored. All the pronged mountains of the Alleghany table-land have their summits of conglomerate and coal measures underlaid with more or less of these beds of XI ore.

At the Towanda coal mines in Bradford county, the following section is seen:

	Feet.
Conglomerate in a massive plate, ...	30
Flinty thin bedded sandstones, forming the rapids and falls on the head waters of the mountain brooks, without intercalations of slate	30
Coal A (80 feet below coal B) . . .	from 1 to 3½
Flinty thin-bedded sandstones	25
Ball ore, in shale and fine clay	
Flagstone rocks	50 to 60
Plate ore, grey, in variegated clays (100 ft. below A) .	3
Grey sandrock	70
Red shale XI, upper band, at least	45
Grey rocks then follow, under which comes the	
Red shale XI lower band, and then	
Pale-green grey very thin flagstones X, for several hundred feet.	

This plate of grey carbonate of iron,[7] three feet thick, divided diagonally into large tabular masses and reposing upon a variegated clay of extremely fine texture, like fuller's earth, comes out under a romantic cascade, and fills the bed of the torrent with its fragments, some of them several feet in length.[8]

At Cash's (Mason's) Opening on Towanda mountain, coal A under the Conglomerate, one foot thick, has a bed of grey carbonate of iron of a very fine grain and great weight connected in some way with it. It comes out in pieces 6 or 7

[7] Johnson's Analysis gives to it earth 30 per cent, oxygen 14 per cent, water 24 per cent=iron 32 per cent.

[8] Report of J. P. L. to Mr. Perkins, 1853.

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inches thick. On Fall creek where the former section was made, a bed of shale 15 or 20 feet below coal A, and 2 or 3 feet thick is full of nodules; and the same shale and ore occurs on the Barclay property on Coal creek. Thus however the seventy feet of iron ore strata at Blossburg are represented on Towanda mountain.

At **Ralston** (on Towanda mountain continued westward between two parallel anticlinal axes,) J. T. Hodge reported in 1840[9] the Conglomerate XII from 45 to 150 feet thick, the top formed of a solid bed of white sandstone 60 feet thick, forming precipices everywhere along the brow of the mountains, the haunt of innumerable rattlesnakes and the floor of a magnificent primæval pine forest, in the solemn silent shades of which may still be heard the frequent long sighing fall—softened by distance—of some giant stem exhausted by a thousand years. On Dutchman's run a slide had made a clean section of the mountain side from the coal down to the Devonian base. Four feet below the Conglomerate, in a bed of dark shale (representing again the coal), lies the ore, several feet[1] thick, in irregular knotty lumps closely bedded in soft reddish and pure white clay, and forming half the bulk of the stratum. It is a white crystalline protocarbonate of iron resembling a fine-grained sandstone or magnesian limestone, incrusted with brown oxide.[2] Since Mr. Hodge visited the place, and in fact since the Blossburg beds were fairly opened, the Ralston ores have been developed, and the lower beds of Blossburg found in their proper places here (1854).

To the northwest the ore extended to the Fourth Great Basin where it has been wrought 8 miles northwest of the Great Meadows, beyond Wellsborough.[3]

This ore has been seen or opened on in a hundred places along the Alleghanies to the southwest, wherever in fact, the anticlinal axes between the first four basins of bituminous coal bring up the base of the Conglomerate and the red shale of XI. But nowhere has it been used for furnaces until we approach the

[9] Fifth Annual Report, p. 137.

[1] At Red run 34 feet thick (Hodge, Fourth Annual Report, p. 138). Mr. Rogers makes the mistake of 14, in copying him. Final Report, ii. p. 470.

[2] Analysis by Dr. Rogers, p. 201:—Protoxide iron 41.22, silica, etc., 28.80, carbonic acid 24.00, water 4.28, alumina 1.00, lime 0.50.

[3] Hodge, Fourth Annual Report, p. 149.

Maryland and Virginia line. In Broad Top it has been already described.

On Lick run near Farrandsville Hodge gives the following section:

Conglomerate, XII, merely a flaggy white sandstone.	
Red shale, containing two beds of ore, twenty feet apart, one 6 and the other 10 inches thick. "The quality is good but the quantity insufficient."	30 feet.
Grey Sandstone like X . . . . not less than . . .	250 feet.
Red Shale, . . . Lower band[4]	65 feet.
Grey Sandstone, with a few pebbly beds, ...	

Mr. Rogers is so unfortunate in this and some other sections in his Final Report as to misread the reports of his assistants and *invert* the section, placing as he does in the next sentence, the two iron ore beds in the *Upper* red shale, instead of in the *Lower.* His work is full of such blunders, the discredit of which would have been saved him had he given proper credit to his various authorities wherever it was due, or rather republished their reports in their own language, as he should have done. The ore in this lower bed of red shale seems to be represented in the Blossburg (Tioga) region by the Wilson creek ore, 100 or 200 feet below XII.

In **Somerset and Fayette counties** Hodge and Lesley reported it at various places, but no doubt it will be found hereafter of a workable thickness in the wild country of Clearfield, Clinton, Centre and Cambria further north. North of Altoona it is very thin. Between the two branches of the Moshannon its outcrop is everywhere marked by bog ore springs. The Philipsburg openings never yielded much ore. On Muddy run, between Clearfield and Cambria, fine bogs come from its outcrop. In the Second Basin at Karthause its appearances are promising. The Karthause furnace mined coal-measure-ores and not those of XI. Bog ores occur along under the outcrop of XII on the Sinnemahoning waters in the Third Basin, and can be traced southwestwardly as far as Warner's or Caledonia. Two miles above this place on Burnet's branch the hard ore appears in a fine natural exposure, 8 feet above water level, under overhanging cliffs of the Conglomerate, as a solid bed (with very little shale) between 3 and 4 feet thick, the ore like that de-

[4] See Fourth Annual Report, p. 130, and Final Report, p. 470.

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scribed by Hodge at Astonville. Under it is fire-clay and over it nodules of ore scattered through 3 feet of brown shale, under 1 foot of black shale, on which presses the Conglomerate sandrocks. We have here again the representative of a coal seam over the ore. Passing over the anticlinal Elk mountain into the Fourth or Toby creek Coal Basin a line of bog ore springs discover the ore at the base of XII along Clarion river. Still further north the ore betrays itself by lines of bogs, as at the Red Mill, near Instantur, in the Fifth basin; between Smethport and Warren; on the Potato creek and Tuniangwant road, and five miles south of Lafayette. The ore itself is obtained six miles north of Smethport, where a vast bog spreads over the hill slope within fifty feet of the summit. Rogers thinks this fine textured ore with a white core to be of considerable value and it is certainly of great extent. Five specimens analyzed by Dr. Owen from McKean county, gave:

Protoxide iron . . .	22.61	20.09	23.24	36.00	8.05
Peroxide iron . . .	7.86	12.04	12.24	10.00	60.45
=Iron	23.10	24.01	27.35	35.00	48.65
Carbonic acid . . .	16.50	18.00	17.20	24.65	5.70
Insoluble silicates . .	48.50	38.50	38.50	25.00	17.00
Lime	1.50	4.50	2.00	1.50	.50
Alumina	1.50	4.00	3.50	1.00	4.00
Magnesia	1.40	1.40	1.40	1.25	.36
Phosphoric acid . .		.50	.tr.	.30	
Sulphur		.tr.		.06	
Water		0.80			3.50

Returning to Southern Pennsylvania, to Cambria and Somerset counties, bog ore springs show the place of the solid ore of XI in Burgoon's gap, at the Pennsylvania railroad summit and along the Alleghany mountain, sometimes on the sides of the gorges and sometimes on the broad, gentle, western slope of the mountain, near the summit knobs. Loose pieces of the ore were dug near the head of Incline Plane 7. At Conover's fork the bog springs are a mile west of the summit, XII being 50 feet thick, the dip being 15° to 20° west. It appears

with the fossiliferous limestone in Flagherty's gap east of Berlin, and in the gorge of Castleman's river through Negro mountain, south of Somerset, and in the gorge of the Youghiogheny through Laurel hill west of the Turkey foot.

On the east slope of Laurel hill two miles from Cambria furnace under white sandstone (XII) 10 feet, are red shales 8 feet, red ore 16 inches, then blue and red shale. The ore has been mined also at Laurel hill furnace six miles southwest of the Conemaugh, on the northwest dip, 18 inches thick over white clay and under red shale, under white sandstone.

Formation XI, as it appears on Laurel hill, is a series of alternating red shales and red sandstones, including a massive stratum of calcareous sandstone passing into sandy limestone, the upper surface of which is about one hundred feet below the top of the whole mass. The entire thickness of Formation XI on the Conemaugh is somewhat more than two hundred feet; this it retains as we pursue it southward, though the composition of the several members of the formation undergoes a material change. While this important and well characterized stratum retains generally, in other sections of the State, the character of an argillaceous red shale, this and the immediately adjacent belts contain a larger proportion than usual of alternating beds of compact, grey and red sandstones, which increase in relative quantity as we proceed southward. The shales becoming more silicious, the calcareous sandstone, above mentioned, grows also more calcareous, passing in some places into an excellent limestone occasionally thirty feet thick.

The iron ore so frequently to be met with in the upper part of this formation, is not seen in the Conemaugh, but following the belt southward along Laurel hill, we find many signs of it, as where the Johnstown and Ligonier turnpike crosses the ridge. At this point the quality of the ore is not promising, while, upon the western slope of the mountain, the limestone, which underlies it, is quarried and used to some extent. The calcareous rock shows itself likewise at the crossing of the Somerset turnpike, but unaccompanied by indications of the iron ore which ought not to appear in contact with it, but in its vicinity. It exhibits here, as in many other places, in a very remarkable degree, the action of violently and irregularly eddying currents at its formation, the often massive beds showing innumerable oblique and meeting layers that plainly mark its unequal deposition.

Still further south, on the summit of the mountain, at the head of Garey's run, the iron ore of the red shale is exposed in a very accessible manner. It occurs on a large tract, the surface of which slopes gently and uniformly to the southeast in obedience to the general inclination of the strata, the ore band occupying the uppermost layers. This ore has been used at Fayette furnace, on Indian creek, being got by stripping and turning up the soil and superficial shale to the depth of 1½ to 6 feet. At a spot where we caused the ore band to be exposed, it measured 8 inches in thickness and proved to be of excellent quality. It is said to have occurred in some spots as thick as 3 feet when it was worked. The line of highest land along the mountain ranges a little west of this tract. The crest consists of Formation XII, a somewhat lower parallel ridge of which two miles further east, bounds the red shale tract on the lower side. In a little ravine which intersects the easternmost of these sandstone ridges appears the iron ore in large slabs, lying loose in the channel of

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the stream. This is on the property of Mr. John Dull, about four miles south-southeast from Garey's. Some of the slabs of ore are 6 inches thick. Appearances here indicate the existence of two layers of the ore. A seam of excellent coal, 2 feet 6 inches thick, lies over the ore at a distance of about thirty feet. This bed probably belongs to a thin lower group of coal rocks which, in this southern section of the State, interpolate themselves as a separate formation between the upper surface of the red shale and the lower limit of Formation XII. These we shall have occasion presently to describe, when treating of the corresponding part of the next western or Ligonier basin, where they are more developed. They make their appearance in the prese t basin at least as far north as the neighborhood of the Stoystown turnpike, where, at the head of Jones's creek, we find these carbonaceous rocks regularly interposed, with a thickness of about thirty feet between the red shale Formation XI and the sandstone Formation XII. Here the inclosed coal seam is only 9 inches thick; it lies about 30 feet above the iron ore of the red shale and reposes immediately beneath the rocks of Formation XII, the total thickness of which, at this place, does not exceed thirty feet. But south of the Youghiogheny in the Ligonier basin, west of Laurel ridge, and near Stuart's furnace, the coal bed under the conglomerate is 4 feet thick and 20 feet beneath the iron ore, which lies in four layers in brown shale, two of them within three feet of each other, the upper one 1 inch, the lower from $1\frac{1}{2}$ to 3 inches thick. Four miles south of the furnace near the National road two layers yield eight inches of good ore.

The iron ore of Formation XI is seen near Henry Whipkey's, on the Clay turnpike, where it occurs at a small distance beneath Formation XII in several bands, one of which measures 5 inches, and another 2 inches. Here, however, more digging than we had time to bestow was requisite before we could decide the exact position and value of these layers. South of the Youghiogheny in this basin, the ore has not yet [1840] been minutely traced, but of its existence we have had evidence in the bog ore deposits of the springs. These are seen on the other side of the mountain, at the crossing of the Turkey Foot road over a branch of Meadow run, which descends into the basin next west.[5] It also occurs on Chestnut ridge where that is crossed by the Clay pike.

Two miles east of Blairsville in the gorge of Chestnut ridge where the Devonian rocks appear upon the great anticlinal separating the Second and Third Basins, C. Hill's ore of XI is a bed of close nodules, $1\frac{1}{2}$ feet thick, immediately overlying the limestone of XI, two feet of it visible and few fossils. The ore is exposed along the river for two miles over the arch, on the terrace under the cliffs of XII. At J. Hill's on the towpath the solid ore 18 inches thick has over it nodules scattered through 3 feet of reddish shale, over which are 15 feet of flagstones and then a limestone 2 feet thick under a coal bed 4 feet thick.[6] If this be not all that is left of the conglomerate then there has been some mistake in confounding this ore of the lowest coal measures with the ore of XI.

[5] Hodge and Lesley, Report in Fifth Annual Report (1841), page 85.
[6] Fifth Annual Report, p. 65.

Near the old furnace on Jacob's creek on Chestnut ridge three miles southwest of Harman's, the ore of XI was formerly wrought, in several bands, in all 8 inches thick.

On the west slope of Chestnut ridge the ore has been but little noticed between Blairsville and Jacob's creek. In Whitemill creek gap, above Breakneck furnace at its entrance, the red shales and limestone are seen, the latter 4 feet thick opposite the furnace, with the ore 80 feet above it ranging along the terrace under the conglomerate. In the Youghiogheny Gap 2¼ miles above Connelsville the conglomerate forms the riffle at Rothrock's Eddy, and the ore lies immediately under it higher up the river. In Dunbar creek gap the conglomerate, a hundred feet thick, lies on a six-inch bed of coal, under which are olive and dark blue shales with the ore and then limestone. At the Old Union furnace, a mile above Dunbar mill, the conglomerate crops out above the creek 80 feet high. Shute's river gorge also has a furnace in it, opposite and above which stand the red shales, limestone and sand rocks of XI with the ore. At the National road a head branch of Redstone cuts down to the red shales and limestone, but the ore was not discovered.[7] The ore has been discovered and occasionally used in the same range south of the Virginia line.

In **Middle Virginia** it has been discovered at several points in Greenbriar and Monroe counties, but not tested, and not described. (W. B. Rogers, Second Report, p. 83.) Further south it has received no attention.

Passing over to the western Outcrop of the ore of XI in western Pennsylvania and eastern Ohio we can say only that it has been but little seen until it crosses the Ohio river.

In **Mercer county Pennsylvania** the one or two small coal beds beneath the so-called conglomerate begin to assume importance as members of a distinct system, and one of those beds becomes the workable beds of Estill and other counties of eastern Kentucky. At Georgetown in northwest Pennsylvania the shales below the conglomerate and above the coal contain two ore beds one foot apart, the upper 7, the lower 5 inches thick (of a beautiful blue color). The coal bed beneath them is 3 feet thick two miles from the village towards Greenville. In the high ridge west of the Shenango river near Sharon it is even

[7] Dr. Jackson in the Final Report, vol. ii. p. 600+.

4½ feet thick, and extending into Ohio may perhaps be the Warren and Akron bed. The ore of these subconglomerate coals fed the two furnaces on Sandy creek.

E. Kentucky

On its **western outcrop in eastern Kentucky** it is that the characteristic features of this curious formation receive their finest development. The conglomerate forms a wavy line of cliffs from 50 to 100 feet high from Greenupsburg and Hanging-rock on the Ohio across Kentucky into middle Tennessee. All the head waters of the Sandy, Licking, Red, Kentucky and Cumberland rivers break out from this plateau of rock through a wilderness of cañons. The most picturesque allées of inaccessible crags, covered with the ancient forest and inclosing brawling streams, precede the bewildered explorer in all directions. It is the labyrinth of America, through which once passed the slender thread of westward emigration and eastward cattle trade, which, forever broken, now surrounds it on the north and south, leaving its "State roads" to grow up a denser thicket than the forest through which they were originally cut, and its stage routes to be represented by bridle paths. Along the western margin of this secluded carboniferous region and overlooking the lower Devonian country, the ore of XI has been opened in many places. It underlies a coal bed, which underlies the conglomerate. At the Pine Table (a most curious square fragment of the conglomerate, two acres in extent and 60 feet high, left standing on the summit of a hill near the county corner of Estill, Bath, and Montgomery, and weathered into its four vertical sides so as to suggest rudely not only a common table but its four legs) the coal bed is 30 feet beneath the lower edge of the conglomerate. Elsewhere the distance varies and diminishes sometimes to a few feet or even inches. Under the coal are coal measure shales from 30 to 50 feet, brown and ferruginous, and piled upon the ore bed, which is from one to three feet thick and lies directly upon the sub-carboniferous limestone (of XI). It is of this ore that Owen speaks when he says in the first volume of his Report, page 200:

In **Carter county, on the waters of Tygert creek,** good ore of the class of hydrated oxide occurs, yielding 50.07 per cent of iron. (See No. 12 of Dr. Peter's Report.) This ore occupies a different geological position from the regularly stratified ores just described, belonging to the coal measures; since it is found in connection with the sub-carboniferous limestone, very much after the manner of the ores of the Cumberland and Tennessee rivers, in the western part of

Kentucky, which have already been treated of in general terms in first chapter of this Report. So far as my examinations have yet been carried, it seems to be most abundant in the dividing ridge between Tygert and Kinniconick, near the confines of Lewis county, near Mr. Macleas, where the belt of the sub-carboniferous limestone is wider, and better developed, than it is in Greenup county. This belt of sub-carboniferous limestone widens in its southern range; near the heads of the Buffalo branch of Tygert creek it attains its greatest elevation in Carter county; bearing thence to the southwest to the waters of Triplett creek, in Fleming county. I have not yet had an opportunity of following it in that direction beyond the confines of Carter county.

Kenton furnace H 523 and New Hampshire furnace H 525 use this sub-carboniferous ore of XI, an analysis of which is given by Owen in his first volume, page 77.[8] It is labelled "*Speckled Iron Ore," from N. H. furnace replacing limestone ore, often over chert, then not so good, Greenup county Kentucky*—

Peroxide iron	20.000	=17.927 metallic iron.	
Protoxide iron	5.040		
Insoluble silicates	49.940	Silica	35.4
		Alu'na tinged with iron	14.0
		Lime and magnesia	0.5
Alumina	13.500		
Soda	4.502		
Magnesia	.362		
Potassa	.885	Water	5.110

The chert here spoken of is not that of the burstone deposit described further on as characteristic of one of the principal iron ores of the coal measures, but a local prophecy of that more general fulfillment. It supervenes between the top of the sub-carboniferous limestone and this New Hampshire furnace ore sandstone roofing, and thus replaces more or less the ore itself. It contains sometimes a large amount of alumina and soda and a considerable amount of potassa and phosphoric acid, which was to be expected, since the animal remains of this horizon are abundant.

In the **southern tongue of Pulaski county,** says Owen,[9] the black thinly laminated shales under the conglomerate, contain at every locality where they outcrop, quantities of carbonate of iron, even in more considerable masses than at the falls of the Cumberland in Whitley county (notorious as the "silver mine" locality), where a section reads as follows:—Sandstone;

[8] Repeated on p. 198.

[9] Vol. i. p. 235, 236.

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coal 10 inches to 3 feet; sandstone forming the escarpment above the falls 90 feet; top of the falls; massive conglomerate beds (XII) 48 feet; black shale with clay iron stones etc. 12 feet; sandy shale 6 feet at foot of falls. The ore here contains sulphuret of iron and zinc, a little lead, antimony and arsenic, and some *scarbroite*. The localities referred to above are on the head of Indian creek; in Rockhouse valley; on Sam's Beaver and on Sloan's South forks. In the first locality the ore would equal perhaps a continuous band of 1½ to 2 feet. On the east side of the Cumberland river in Whitley county opposite Williamsburg the King's coal section shows much carbonate of iron in the shales near the river under the overhanging cliffs of conglomerate.[1]

In **Bath county** towards the head of Clear and Stone quarry creeks, the ore of XI is traceable along the top of the sub-carboniferous bench which runs along at two-thirds the height of the hills above the streams, over the clay freestones, over the Devonian black slates. Sometimes there lies six or eight inches of ochreous earth between the limestone and the ore bed, which itself lies imbedded in a grey, yellow and pink clay. If the ore lies directly on the limestone the miners say it is "burnt out." It varies from 1 to 1½ feet but rises even to 4 feet, and has above it (15 feet) the lowest bed of coal, consisting of 2 feet of coal over and 1 foot under 1 foot of parting clay. The coal lies about 24 feet below the conglomerate. Dr. Owen suspects after careful examination that a specimen of ore found down the creek and which when analyzed afforded a considerable percentage of copper, came from this ore bed. Some specimens have a peculiar dark appearance as if it might contain black oxide of copper, but two such specimens when analyzed showed none.

In **Rowan county** the ore of XI seems to be silicious but has scarcely been investigated.

In **Estill county** the ore of XI is partly black and partly kidney ore, principally carbonate but mixed more or less with limonite. The old furnace at the head of Miller creek finds its ore over the sub-carboniferous limestone, which here, as in Powell county, is divided into at least

[1] Owen's Kentucky, Vol. i. p. 240.

two members by over one hundred feet of sandstone. Cottage furnace was lately built to run on this ore where it can be reached by stripping only ten feet of cover off, and averages 9 to 12 inches thick, lying 15 to 20 feet beneath the cliff of Conglomerate sandrock (over the lower layers of which are a few small beds of ball ore). At one opening it measured 22 inches, with three clay partings, making 16 inches of ore in all. At the California bank it is more highly oxidized and often deep brown. Between Red and Rock lick creeks, on the War fork, Breet creek, etc., the ore will probably be found under the coal, which is there 3 or 4 feet thick; but it is an unexplored region yet. In fact from this on to the Tennessee line, through Rockcastle, Pulaski, Wayne and Cumberland, no iron ore is reported upon the subcarboniferous limestone. Nor does any extensive deposit of it seem to be noticed around the western coal field, upon the subcarboniferous rocks which range through Sampson, Logan, Todd and Christian counties. Here the great ore deposits of the Cumberland and Tennessee rivers at a somewhat lower geological level (?) take its place.

The sub-carboniferous rocks consist of several members, as described by Owen.[2] Immediately under the Conglomerate occur locally soft grey, greenish, purple and reddish shales or marly deposits sometimes of great thickness, the "long running rock" of the salt borers. Two or three hundred feet beneath the Conglomerate (on the Tradewater) is an upper mass of limestone, 50 feet thick and characterized by numerous *Archimedes*, with *Pentremites* and interesting *Crinoids*. One hundred feet further down is a second lower mass of limestone 150 feet thick, containing *Pentremites* of large size, one being 2⅝ inches high by 2½ across the basal plates. Then follows (downwards) 200 feet of sandstone close grained, smooth bedded, and hard as quartzite, occasionally containing fine *Lepidodendra;* this rock is No. X of the Atlantic outcrop mountains, and over it are thin coal beds representing the south Virginia coals. Beneath this sandstone comes the great body of the Subcarboniferous Limestone of the west, the *Lithostrotion* beds, so called from a fossil reed-like coral, converted usually into flint, which abounds in them and strews the surface of the Barrens, those originally open prairies of Kentucky, now timber-grown and full of sink

[2] Vol. i. p. 79.

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holes. The bottom of this formation graduates into clayey and hydraulic limestones, and semi-crystalline beds of *entrochites* and *reticulated corals*, and *spirifer striatus* (?) These *Lithostrotion* beds, says Owen, are the repositories of the west Kentucky (Trigg, Lyon, Caldwell, Livingston and Crittenden counties) and west Tennessee iron ores, and his views of their origin are important. He describes them as lying always unconformably over the edges of the limestone beds on the slopes of the hills, mixed very irregularly with ferruginous clay and chert and conveying the impression of an infiltration.

Although great uncertainty exists as to the extent of any bed, still such a degree of uniformity is observable in the general bearings of the individual deposits that he has been led to suspect their connection with regular veins of determinate bearing, traversing the limestone formation of the country. In Crittenden and Lyon counties he found them ranging north 18° to 20° east, as in Calloway county Missouri and Hardin county Illinois, and was able in several instances to trace these ores into fissures of the Sub-carboniferous Limestone with well defined walls, bearing from north 15° to 22° east and from 24 to 27½ feet apart. In these fissures he thinks the superficial deposits will be found to originate and that the ore there exist in a more concentrated form and a lower state of oxidation; that highly heated carbonated waters have dissolved both iron oxide and silica out over the vents and down the declivities, where they dropped the protoxide to form peroxide of iron under the action of the atmosphere, while the principal body of silica, specifically lighter, segregated as chert among the ore, while the commingled clays came from the washings of the crevices and seams of the limestone; dripping into vacancies they formed stalactite *pipe ore;* oozing through coarse gravelly earths and lumpy clays they coated silicious and argillaceous nuclei and produced *pot ore;* percolating through porous earth they made *honeycomb ore;* the quantity of ore depending on the duration of the overflow, the configuration of the surface, and the degree of saturation.

It is impossible to agree at once or entirely with a theory so essentially volcanic, especially when we consider the fixed geological horizon at which and the great extent of country over which these deposits occur, and how their nature accords with

the constitution of all the limonite beds of the Palæozoic system, derived we are assured from the peroxidation of various beds of carbonate of iron. A description of these deposits in Tennessee is given in the chapter on brown hematite ores preceding this, and while much doubt is cast upon their precise subcarboniferous age, and much difficulty must be overcome in explaining their precise mode of production, here seems to be the place in the order of description of the ores of the United States where they ought to come.

Ascending now into the coal measures proper, above the lower Great Conglomerate, commonly assumed as the basis of that system, we have a difficult task before us, to present in any clear, concise arrangement, the numerous beds of carbonate of iron which are interleaved among the beds of coal and limestone, in the shales and sandstone intervals, and even in the very beds of coal themselves. Their general characteristics have been discussed at the beginning of this chapter. It would require a volume to catalogue all the localities where they make their appearance at the surface. It is possible here only to describe the areas within which they occur, the belts within these areas into which their more important exhibitions arrange themselves, the beds of coal which are more immediately related to their more conspicuous layers, and the principal centres of manufacture which have caused the largest groups of mines.

The areas within which the coal measure carbonate ores occur are of course the coal basins of the east and west, the anthracite, semianthracite and bituminous regions of Pennsylvania, western Maryland and Virginia, eastern Ohio, Kentucky and Tennessee, northern Alabama, central Michigan, western Kentucky, southern Illinois, the western parts of Iowa and Missouri and the east of Kansas. The deepest parts of these areas are the Pottsville, Shamoken and Wilksbarre anthracite basins, the region southeast of Pittsburg and Wheeling, the centre line of the west Kentucky basin, and the eastern border of Kansas. Other things being equal, the deeper the coal basin the more numerous the layers of iron ore; but in point of value to the manufacture of iron, the ores are chiefly confined to the lower coal measures, or the rocks towards the bottoms and therefore round the shallower parts of the basins or areas. Hence

The principal belt of ore deposits encircles the central coal areas. To explain this more fully,—the carboniferous system falls into four divisions, thus:

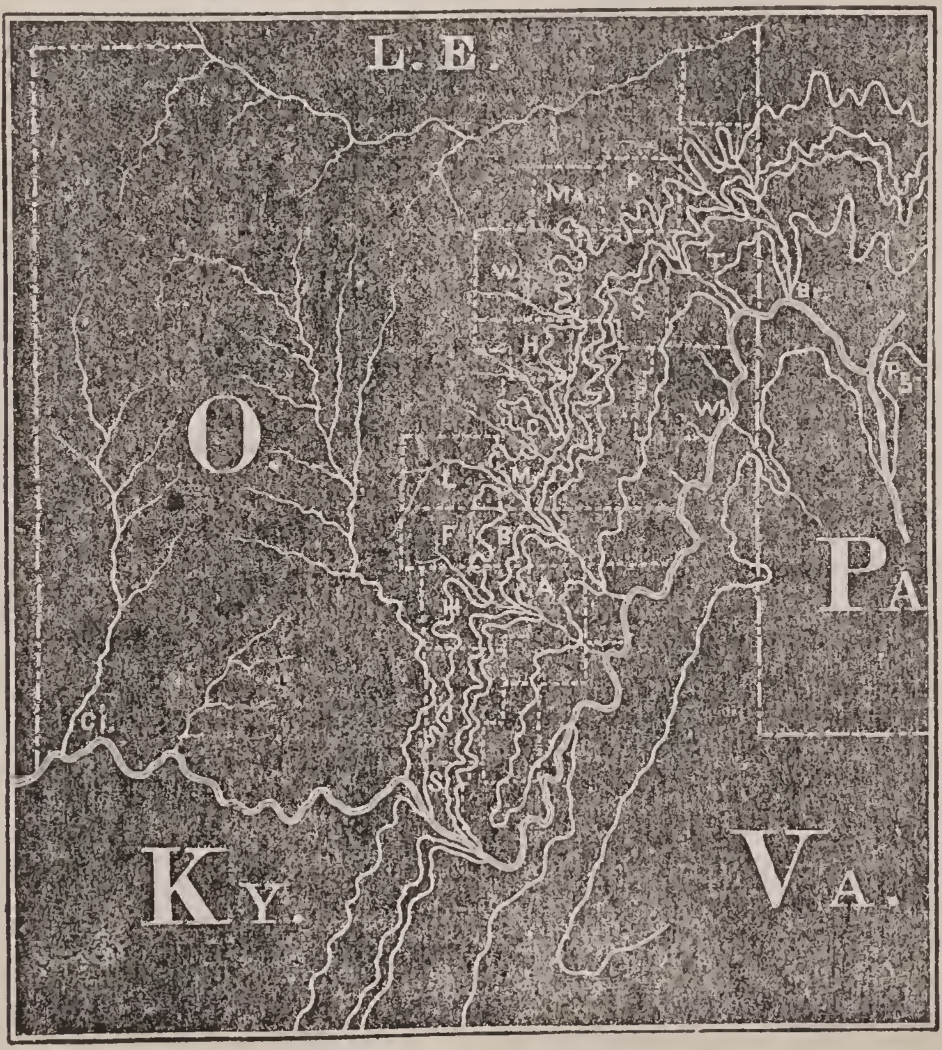
Upper Barren Measures, in southwestern Pennsylvania;

Upper Coal Measures, of Wheeling, Pittsburg, Madisonville;

Lower Barren Measures, from 400 to 700 feet thick;

Lower Coal Measures, of Johnstown, Freeport, Athens, etc., etc.

These formations lie the one upon the other, and all upon the Great Conglomerate at the base; they occupy therefore successively smaller and smaller areas, each lower one spreading its scalloped and fringed edges out beyond the equally ragged limits of the one above it, until the uppermost of all is seen confined to the country surrounding the extreme southwestern corner of Pennsylvania,—the high sheep-growing coalless table land of the Coal Formation. The lowest layers of the lowest coal measures on the contrary may be seen, by looking at the map of Pennsylvania given on page 534, to stretch long fingers



out towards the New York line; and on the preceding map of Ohio to cross the State in a fringe through Trumbull, Portage, Stark, Wayne, Holmes, Coshocton, Múskingum, Licking, Perry, Fairfield, Hocking, Jackson and Scioto counties. A general dip southeastward of 10 or 20 feet to the mile prevails between this waving outcrop and the Ohio river, and brings the Lower Barren measures and then the Upper Coal beds into the hill tops and finally beneath the level of the rivers. The Ohio river is seen flowing round the Upper Coal measures in the soft shales of the Lower Barren measures as far as the south point of Ohio, when having reached a point opposite the deepest place in the coal field, it turns at a right angle and breaks out northwestward through all the lower coals. Referring now to the photo-lithograph map of western Pennsylvania and eastern Ohio, in the Guide, it will at once appear how all the numerous furnaces of these States are situated on a great belt, broken indeed by lateral intervals,[2] but based upon the iron ores of the Lower Coal measures. In these Lower Coal measures are many layers of ore, but one, the buhrstone ore, surpasses in importance, and is in fact the chief occasion of the numerous iron-works which mark that map. The other beds are subordinate enough to it to warrant us in saying that the manufacture of iron in the west would in its absence have been postponed for many years. It is necessary therefore to define the place of this bed in the series, and at the same time its principal congeners will find their places also.

The Lower Coal Measures in the Alleghany river region, where the greater number of furnaces are, as described by McKinney, Boyé, Holl, Jackson, Lesley and others of the Pennsylvania survey, form a system by themselves included between the triple conglomerate at the base, and the triple Mahoning sandstone four hundred feet above it, and may be approximately represented by the section on the following page.

The proportions vary frequently as we might expect, and rapidly from mile to mile; but so constant and on so grand a scale were the agencies which formed the members of the system, so steady were the oscillating movements of the continent and so continental the expanse of watery marsh and penetrating

[2] These intervals are due partly to local diminution in the great ore deposits, but chiefly to the wildernesses left between the rivers and great lines of railroad transportation.

Lower Coal Measures.

MAHONING SANDSTONE, in triple division, in all, .	75	feet.
SHALES, ...	50	"
coal E the Upper Freeport sometimes over	6	"
limestone e, ...	8	"
SHALES, ...	50	"
coal D the Lower Freeport bed, over .	3	"
SANDSTONE with thin coal, ...	70	"
SHALES with thin coal beds, ...	100	"
coal C the Kittanning (Cannel), seldom, .	4	"
SHALES, sandy and clayey, ...	25	"
ore and buhrstone, average $1\frac{1}{2}$, from 1 to .	10	"
limestone c (encrinal) . greatest thickness	23	"
SHALE, sandy . . . . over	30	"
coal B . . . . . . less than	4	"
SHALES with thin coal seams, ...	40	"
coal A . . . . always thin	2	"
CONGLOMERATE sandstone, ...	15	"
SHALE, sandy	50	"
CONGLOMERATE sandstone, ...	30	"

sediments that the main features of the section as a whole suffer but little change as we pass eastward towards the anthracite or southwestward towards the Kentucky fields. The Top rock is the Mahoning sandstone everywhere, on Broad Top, in the Cumberland and Somerset, Ligonier and Monongahela basins and in southern Ohio. The interval indeed on Broad Top is but about 200 feet, and in Somerset 400 feet, but the two principal coal beds lie always the one near its bottom and the other near its top, the ore maintains its status at Johnstown on the Conemaugh, as at Hanging rock on the Ohio, and the very fossil shells, leaves, fruit and stems of trees, preserve throughout their several and separate stages and mark the separate beds.

The **Lower Barren Measures** are equally extensive, but very differently characterized, namely, by bands of red shale and massive beds of limestone at their upper limit. There is in many places under this limestone a coarse conglomerate-like sandrock (as at Armagh for example on the Conemaugh) which may be assumed with advantage as the classical upper limit of

this second division of the Carboniferous system, which varies locally in its dimensions several hundred feet. At Pittsburg its section may be represented thus:

SAND and SHALE,	30	feet.
limestone j	4	"
SHALE, red,	12	"
limestone i	4	"
SHALE, yellow 10, buff 18, red 4,	32	"
limestone h	3	"
SHALE and slaty sandstone,	10	"
marl, red,	10	"
SANDSTONE, grey building stone,	70	"
SHALE, olive,	100	"
limestone g	2	"
coal G	1	"
marls, red and blue calcareous,	20	"
SANDSTONE, slaty,	30	"
SHALE, sandy thick, say	50	"
coal F	1	"
MAHONING SANDSTONE, triple	75	"

In some places these red shale bands are from 30 to 50 feet thick and mark the country so plainly that the traveller least experienced in geology must recognize their regular recurrence. The barrenness of this section in coal and iron is as marked a trait in the anthracite region on the one side as in the west Kentucky field on the other, and the limestones which it contains possess far fewer forms of life than those below it or above.

The **Upper Coal Measures** lie also between great sandrocks, assuming the one last mentioned as a fixed horizon. At its upper limit lies the great Anvil Rock of Kentucky, represented at the extreme eastern limit of the bituminous area, by the conglomeritic sandstone over the three great beds of Salisbury in Somerset county Pennsylvania. These three beds are the three principal Monongahela (or Waynesburg and Greensburg) beds of Jackson and McKinley's reports, the beds of the Wheeling region on the Ohio, the Nos. 9, 11 and 12 of Owen, Lyon and Lesquereux.[4] These, even at their maxima localities in western Kentucky are but 5, 8 and 4 feet thick; but in Somerset county Pennsylvania they are 10, 11 and 15 feet in thickness,

[4] See vol. iii. Owen's Report of Kentucky, 1857.

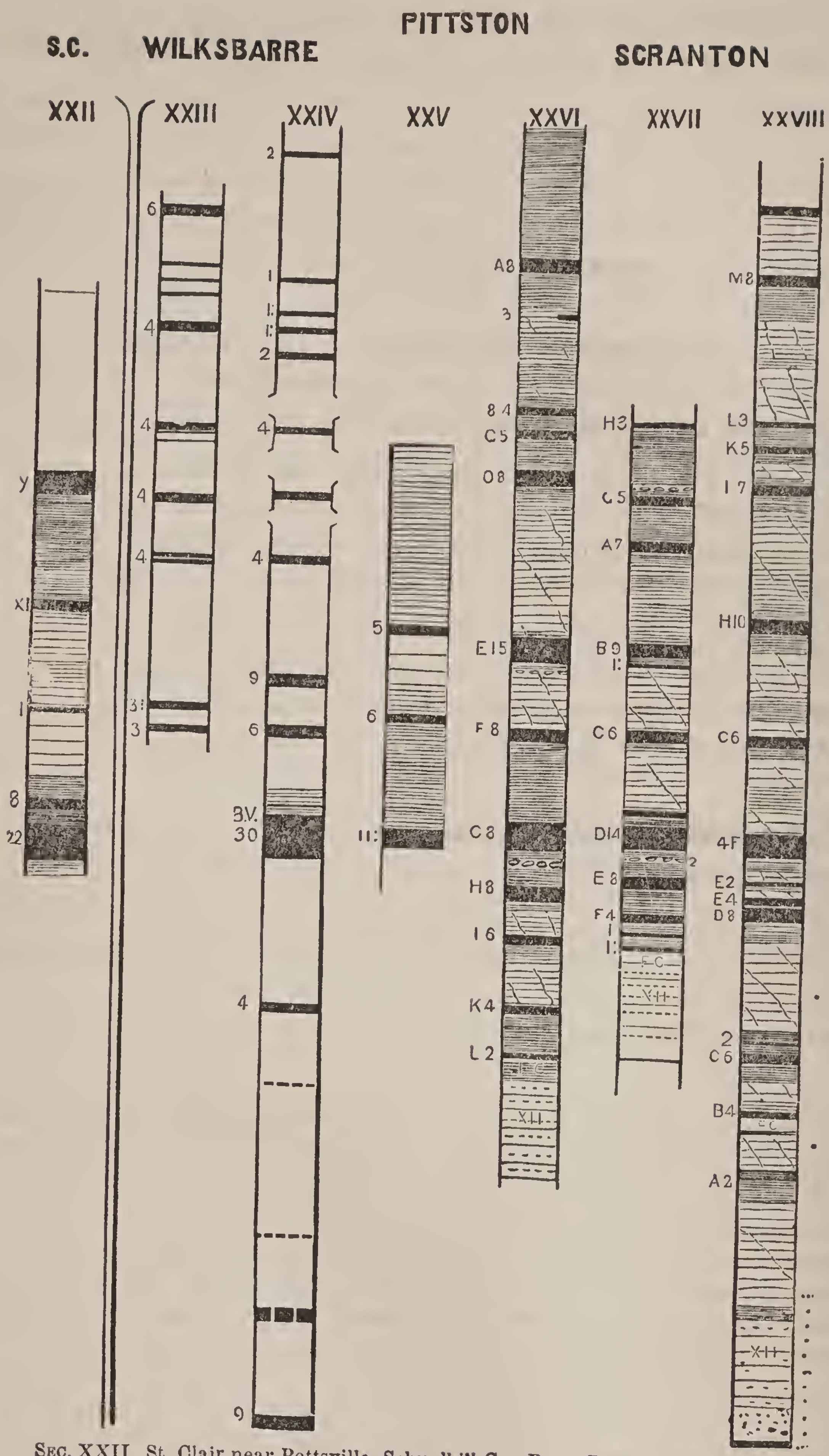
in a six mile area; and in the Dauphin county anthracite coal basin they are quite as large.[5] In spite therefore of the enormous local size of the lower anthracite beds, the Mammoth and Jugular veins, and the general five and six foot thickness of their representative beds B and E in the Lower Coal measures of the west we may hesitate to give to the Lower Coal measures rank above the upper in any other respect than that of more extensive area. But in iron wealth there is no comparison between them. In Pennsylvania there is but one place where they have furnished stock for furnaces, namely along the western foot of the Chestnut ridge from Uniontown southwest into Virginia, under the Pittsburg coal bed, where it occurs also in the Somerset basin, and the Frostburg basin. In Kentucky nearly the same horizon (shales of bed No. 9) is marked by vast numbers of nodules of iron ore some of great size and containing shells and petrified wood,[6] and coal No. 7 has black band over it.[7] But the black band on which Alexander's furnace at Airdrie in middle Kentucky was built to run, is at the upper limit of the Upper coal measures, over bed No. 12.[8]

In **the Anthracite region** the general disposition of the beds of coal (marked black), of ore (marked with ovals or circles), of shales (shaded), of sandstones (left nearly white), and of fire-clay beds (left quite white), with their thicknesses in feet is shown on the accompanying plate of vertical sections, with a scale of a hundred feet along the side.

[5] This is not the place for a minute discussion of the coal beds; nor are the conclusions of Lesquereux (see Palæontological report in Owen's third volume) set aside by anything here said. His identification of the Pittsburg coal bed with No. 8 (a thin) instead of with No. 9 (a thick) coal bed in western Kentucky, is cordially accepted. But in an attempt to give a clear bird's-eye view of the Upper Coal measures it would only confuse the view to describe the local disappearance of one and substituted appearance of another. The whole group actually consists of at least six beds.

[6] See Lesquereux Report to Owen, vol. iii. p. 542. [7] Owen, vol. iii. pp. 14 and 524.

[8] Lesquereux to Owen, vol. iii. p. 548.



SEC. XXII. St. Clair near Pottsville, Schuylkill Co., Pa. (P. W. Shaffer.)
" XXIII. Lee's mines, below Wilkesbarre. (A. McKinley.)
" XXIV. Wilkesbarre section. (Logan, McKinley.)
" XXV. West Pittston boring; Wilkesbarre basin.
" XXVI. Griffin Lot, Scranton, W. Basin. (Needham.)
" XXVII. Diamond Mine survey, W. basin, near Scranton. (Needham.)
" XXVIII. Scranton, Wilkesbarre basin. (H. D. Rogers.)

E. Pennsylvania.

In the **Anthracite coal basin** around Pottsville in Schuylkill county Pennsylvania, there are (according to the Report of H. D. Rogers to H. C. Carey, published 1849), two groups of ore beds, the lower one including the great Mammoth coal bed, and the upper one overlying the Black-mine red-ash coal bed of Guinea hill. Describing all these ores together in a descending order, we have:

Near the summit of Guinea hill a two foot and a half stratum of balls, often closely packed, and sometimes 2 feet long each ball, the whole thickness of iron being say 14 to 18 inches; dip 40° southward; iron 26 per cent; mining \$1 50 per ton. Three or four layers of balls, loosely or closely set, or plates of ore, the thickest 4 to 6 inches, 32 per cent ore, lie somewhat higher in the hill. These ores range through the basin and show sometimes a good abundance of materials. Mr. Rogers reported that he "entertained no doubt it was destined to afford an ample supply of a cheap material for iron works." The prophecy may yet be fulfilled, but few men now assign any value to these ores, after ten years of experience and in face of the inexhaustible rich ores of the Lower Silurian and Primary rocks to the south and east. The hardness of the rocks in the anthracite region makes mining more expensive than in the west where the same ores abound.

A little below the Big Tracy coal bed are two layers of ball ore. On the Spohn tract they are 16 feet below the coal, dip 30° south, and would yield 7 or 8 inches of 28 per cent ore in one gangway, costing \$1 75 a ton.

McGinnis's shaft in Pottsville, sunk (absurdly enough) upon the anticlinal axis south of the vein, cuts, at 38 feet down, a 9-foot bed of soft shale in which lie five courses of superior ore (dipping 40° south in the tunnel which offsets in the shale) viz.,—Ball ore, 3 inches; solid ore 6 inches; ball ore 5 inches; solid ore 5 inches; ball ore some inches,=in all say 16 inches, of 33 per cent ore, costing say \$1 50 to \$1 75 per ton to mine.

In the lower white ash series, near Neighley's or Fisher's tunnel in Minehill on the Wetherill tract, a *blue band* ore, 6 inches thick, with balls in black slate above it and black slate below it, was used at the Mt. Carbon Furnace (Pioneer). It was 33 per cent ore, and cost \$2 00 to drive through and \$1 75 to mine in the breasts. At Pinkerton's shaft it is 7 to 8 inches thick with some balls above it, and cost \$1 50 to mine. In the Pinkerton colliery it lies 15 feet above the seven-foot coal (above the Mammoth bed) and is 10 inches of ore in 4 feet of gang.

This seven-foot coal is triple, and has between its two lower benches, cakes of ore 4 or 5 inches thick, "exhibits numerous scales of coaly matter, impressions of sigillaria, etc. and the whole body of the ore is indeed highly carbonaceous" resembling *black band ore*, but without the bituminous matter which distinguishes the latter.

Close under the seven-foot coal, in Silliman and Fisher's colliery, lie large flat smooth cakes of ore from 4 to 14 inches thick and sometimes 2½ feet long, separated by equal intervals in blue fire-clay. Rogers estimates the ore at a 5-inch average, and mining cost at \$2 50, the ore being close-grained, uniform and 33 per cent. It ranges extensively along the south foot of Mine hill, through the Mount Laffy tunnel, in Pinkerton's colliery and elsewhere.

Mann's ore lies 80 to 100 feet below the Mammoth white ash vein on the south side of Mine hill on Mount Laffy, dipping 5° under 200 or 300 acres of soil. Six layers in ten feet of soft laminated slate lie as follows, descending:

Covering of 2 to 20 feet,
Ore balls, coarse, close together, 2 to 5 inches.
Interval of 15 inches,
Ore plate, finer, 30 per cent, 3 to 4 inches.
Interval of 2 feet, scattered balls of good ore,
Ore nearly continuous, good, 3 to 5 inches,
Interval of 2½ feet,
Ore, 33 per cent, nearly continuous plate, 4 inches,
Interval of 1½ to 2 feet,
Ore plate, superior, 37 per cent, 2 inches,
Interval of 15 inches
Ore plate, 40 per cent, one inch thick.

In all the ore is 18 inches thick. It ranges westward along the mountain and can be mined for $2 00 per ton and sometimes even for $1 50.

Here we have an illustration of those sections which seem open to no other explanation than that of original intermitted and quasi-instantaneous protocarbonate deposition. It is hardly to be imagined that so regular a set of layers would follow each other at such short intervals in a travel downwards towards a base of leaching; nor that they were arrested each one by a separate belt of impervious clay; still less that they were converted into such clean *plates* of carbonate from *disseminated* sulphuret of iron, and at different stages so near together, and with so little sign of peroxidation; nor that they were charged with carbon from the coal beds below. They have all the appearance of being actual mud layers originally so spread at short intervals of time over the sea bed; and why not?

One anthracite iron ore locality has acquired some celebrity by originating hopes, which have been disappointed, that the black-band ore of Scotland would be here found rivalled. The Pottsville basin is divided at its western end like the tail of a fish into two long narrow lobes or prongs, the Dauphin basin on the south and the Wiconisco on the north. In Klinger's Raush gap through the northern barrier mountain of the northern prong, where the measures rise from the basin at an angle of 45° the following section is given on page 190 of the second volume of the Final Report.

	Interval.
No. 13. Two small coal beds, 2 feet each and 6 feet apart,	
No. 12. Coal 4 feet good, under sandstone,	40 feet.
No. 11. Coal (Black valley) 24 feet thick,	40
No. 10. Coal (Blackheath, Peacock) 4 feet, good, dip 58°,	20
No. 9. Coal (Lomason or Big vein) 10 feet (4+6),	100
No. 8. Iron-ore-coal, 2 feet, shafted on the mountain.	60

Pennsyl.

	Coal 4 feet solid, parted by 12 feet of slate from	
No. 7.	Coal 11 feet, (at Donaldson 10,) on egg conglomerate,	
No. 6.	Coal small in a shaft upon the mountain,	372
No. 5.	Coal small in a drift,	288
No. 4.	Coal 6 feet, good, in an old drift 100 feet in,	130
No. 3.	Coal 5 feet, with but 2 feet of good coal, in 100 feet,	192
No. 2.	Coal 7 feet, good, crushed, once worked for 173 feet,	87
No. 1.	Coal $2\frac{1}{2}$ feet thick in the shaft	90
	Red shale of XI.—The thicknesses of rock in the intervals are not given but probably were measured on the water level through the gap.	60

The continuous plate of dark grey argillaceous iron ore, very carbonaceous and full of vegetable fossil forms which lies immediately over coal No. 8 of our section, is the black-band ore in question. It is separated from the top layer of coal by 12 inches of black slate and its maximum thickness of 12 inches is maintained for 300 yards in the eastern gangway, but in the gangway on the western side of the gap dwindles to 7 inches. About 2 miles east of the gap it is thin and disappears before reaching the mines at Donaldson; neither is it found, in its well known place, towards the west at Bear gap.[1] Parts of the bed are decidedly pyritous, and although Mr. Rogers seems desirous to speak hopefully of it, all expectation of its manufacture has been abandoned, and it is the only place in the anthracite region where the most diligent search for a profitable black band ore has promised anything to hope for.

In the northern prongs of the bituminous basins a multitude of local outcrops of ore have been recorded but they are of doubtful size and quality and buried in almost inaccessible mountain wilds, or perched on the flat summits of the synclinal mountains. The first locality going west where the ores of the lower coals have been much tried is at Farrandsville on the west branch Susquehanna above Lockhaven, where a great furnace was erected and a quarter of a million of dollars sunk. The ore is a poor nodular stratum in shale under a 6-foot fire-clay bed under the third coal bed. Still further west around Philipsburg the buhrstone ore begins to show itself in its semi-carbonate semi-limonite character with the ferriferous or encrinital limestone under it; and along Clearfield creek are larger quantities. A furnace was once built at Karthaus but with no avenue to market except the deceitful river. Hereafter this will

[1] Rogers's Final Report, vol. ii. page 119.

be a seat of the iron manufacture.[2] John James's section of the ores at the old furnace, slightly corrected by Hodge, is given in the Fifth Annual Report as follows:

	Feet.
Hill summit 565 feet above the river.	
Slaty sandstone and a coal bed 2 feet thick	79
Black slate 1, coal 6, fire-clay 2½ (479 feet)	9½
Brown sandstone	45
Coal 1, fire-clay 2, limestone 3½, shale and **poor ore** 1 foot	7½
Brown sandstone	25
Coal 3, slate 1½	4½
Grey sandstone	37
Coal 3¼, shale (with 26 inches good **Kidney ore**) 11	14¼
Coal	1
Brown sandstone and slate	21
Coal 3¾, fire-clay 2½	6¼
Brown sandstone	35
Coal 1, ferruginous fire-clay 3, shale (with 25 inches of good "**red**" **iron ore**) 11¾	16
Shales and slates with a little unimportant **ore**	22
Coal 1	1
Brown rock; Coal, thin seam; Conglomerate and sandstone XII, to river	240

Nine miles higher up the river the red ore is thicker.

In the Broad Top coal basin in Middle Pennsylvania is a fine exhibition of plate carbonate ore, on a high hill near Hopewell, over Sandy creek, and high up in the Lower Coal Measures. It is 4 feet thick, underlies a coal bed of equal size, was used for 20 years to make a rather coal-short iron, and is about to be worked again in connection with the red-short brown hematites and the fossil ore of the Upper Silurian rocks a little to the west of it. It occurs in other parts of the mountain but has nowhere else been exploited.

At **Johnstown on the Conemaugh** the iron ores of the Lower Coal measures have received perhaps their best examination. The town and furnaces and rolling mill of the Cambria Company occupy a triangular plane where the two branches

[2] See J. T. Hodge's description of the ores in the Fifth Annual Report of the State Geologist for 1841, pages 49, 50.

S. W. Pennsylvania.

of the river meet, between abrupt hills 300 or 400 feet in height, around the sides of which crop out, in horizontal layers, alternate coal, clay, sandstone, limestone and iron ore, thus:

	Feet.
Limestone 1½ to 2 feet, coal ½; interval of 12 feet . .	. 14
Iron ore in two bands, 2 to 3½; interval of 60 feet	. 63
Coal 3⅜; interval containing iron ore 45 feet . .	. 49
Coal 2½, slate 1½, limestone 3, shale interval 28. .	. 35
Coal 3½, fire clay 1, hydraulic cement 4½, fire clay, etc. 10; then a shale interval with **6 to 12 inches of ore,** 50	. 70
Coal 3⅓ at water level; interval with two thin coals 45	. 48
Coal ⅔, and a small interval of shale, 12 feet . .	. 13

Conglomerate No. XII.—The iron ore wrought so extensively at the Iron Works is near the top of the section, overlying the highest workable coal about 60 feet, and the water of the river about 250 feet. On the south side of the river it does not appear to be as important a bed, but when the hill at present mined is exhausted there stands another ready on the north. The ore bed roof and floor are slate; the upper bench of ore, from 1½ to 2½ feet thick, is close grained, compact, dove-colored, comes out in square blocks, and oxidizes at the outcrop always to a shell. By analysis it yields from 51 to 52 per cent. The lower ore bench, separated from the upper by a thin seam of clay and running from ½ to 2 feet thick, is a light blue limestone-looking ore weathering white on the surface. The two benches thicken and thin alternately, keeping the whole thickness about the same. The furnaces run on coke and often need no limestone flux.

Southeast of Johnstown at the forks of Paint creek, is a very attractive ore locality, where a stratum 8 feet thick has 2 feet of good rock ore with close-set balls, while large nodules lie in the sandstone roof and good ore in the shale below. At the Hogs-back up Stony creek, 1 foot of ore (nodules in contact) overlies a hard ferruginous 1½ foot limestone, 100 feet above the creek and not far from the horizon of the Johnstown ore.

In the **southern part of Somerset county** on the waters of Castleman's river, and the line of the new Connelsville railway connection between Baltimore and Pittsburg, are some still more promising localities. The region between Berlin and Salisbury, famous already for its monstrous coal beds, is destined to be as well known as Johnstown for its iron works. The

iron ores of the Lower Coal measures crop out on each side of the basin, and at Elk-lick falls is a triple ore bed, the lowest bench, 1 to 4 inches, nearly solid, dividing into squarish blocks; the other two, 2 feet above it, contain an equivalent of 4 inches of solid ore. The stratum is continuous down the creek. Ore lately opened within 3 miles (south) of the river was but about 1 foot thick, but many places will be found where it is workable and with the ore of XI in the Alleghany and Negro mountains, mixed with Cumberland fossil ore, brought by railroad, a large amount of capital will some day be concentrated in this old and beautiful settlement.

In **Maryland, Alleghany county**, systematic researches were made in 1836 by the George's creek Coal and Iron Company and published in their annual Report and the same section in Ducatel's State Geological Report for 1840, as follows, in descending order:

Iron ore	1′6″	inches
Fire clay	10″	
Iron ore	2″	"
Fire-clay, ore nodules 2′ shale 6″ coal 6″ shale 2′6″=5′6″		
Iron ore	2′6″	"
Shale and nodules 2′ sandstone 9″ shale 4″	3′0″	
Iron ore	2″	"
Shale	6″	
Iron ore	4″	"
Shale with nodules of ore	3′0″	
Iron ore	1′6″	"
Shale	2′6″	
Iron ore alternating with thin seams of shale	3′10″	"
Shale	1′6″	
Iron ore	3″	"
Shale	1′0″	
Iron ore	5″	"
Shale 5′ coal 8″	5′8″	
Iron ore	6″	"
Coal 1′6″ shale 2′0″ coal 1′6″ shale with nodules of ore 1′0″ fire-clay 1′0″ coal 2′0″ shale 6″ fire-clay with nodules of ore 1′0″	10′6″	
Iron ore.	1′0″	"
Fire-clay 10″ shale 1′6″	2′4″	
Iron ore.	10″	"
Total iron in 55 feet	13′0″	feet.

There were reports by —— —— and P. I. Tyson in 1837; reports by Silliman and Douglass in 1837: reports by H. T. Weld, J. Pickell, Capt. Erickson, F. Shepherd in 1858, which

W. Maryland.

made the thickness of these beds in the aggregate 16 or 17 feet, but Mr. Ducatel says well that not more than 9 feet can be considered workable, and the George creek Company's Report assumed more wisely 7 feet. The workings of a series of years would probably reduce it to 4 or 5 feet. It is a safe rule to take *one-third* of an estimate of Coal-measure iron ore as the probable amount after the surface or outcrop ore has been stripped and gangways must be resorted to.

The **Virginian country** to the south of this has not been explored for iron, but undoubtedly the Lower Coal-measure ores which hold their own so well in going westward through Ohio and Kentucky, are not to be suspected without evidence of fading and dying away along their eastern outcrop.

Passing now over to the north and west, the McKean and Elk county Survey, by the accomplished geologist, Augustus F. Dalson, in 1857, gives perhaps the latest and most reliable statement of the iron ores of northwestern Pennsylvania.[3] In a depth of Lower Coal of above 300 feet, we see

Coal beds No. 13 and 14, of small size.
Iron ore in balls No. 12, in a stratum six feet thick.
Coal bed No. 11, double, six feet, good quality.
Coal bed No. 10, single, three feet, superior, becoming cannel.
Iron ore in balls overlaid by a thin seam of cannel coal.
Coal bed No. 9, solid, 2½ feet, under the ore balls.
Coal bed No. 8, "Bond Vein," 4 feet between one foot cannel.
Iron ore in balls overlying
Coal bed No. 7, two to three feet thick.
Coal beds Nos. 4, 5, 6, small beds accompanied by **black-band and other iron ores.**
Coal bed No. 3, "Splint Vein," the lowest and best, 4 feet thick.
Carbonate of iron No. 2, one foot thick.
Nodular iron ore No. 1, bed 5 feet thick, seventy feet below the lowest coal, cropping out only in the largest and deepest valleys, and known in many other parts of the region.

It must be remembered that a stratum containing ore balls is measured across between the upper and lower limits of the

[3] Second Annual Report to the Stockholders, Philadelphia, 508 Minor street.

balls, and if the rock be hard the practical value of the deposit may be represented by one-fourth or one-fifth of this thickness; if soft, by one-third or one-fourth of it according to the size and number of the nodules. Even the apparent thickness of a "plate vein" of carbonate of iron must be reduced 10, 20 or 30 per cent according to its broken condition, before a judicious estimate of its practical mining value can be made.

In **McKean county northwestern Pennsylvania** the following sections of the lower coal measures made by Dalson, Owen and Needham in 1856 and 1857, will show the aspect of the ore of XI, Rogers's Vespertine (formerly, now Auroral) red shale, as it emerges from under the Alleghany coal measures upon the northwestern outcrop side; as well as the positions of several iron ore beds in the lower coal measures themselves.

Dalson.

	Feet.	Feet.
Coal	4	
Coal	1¼	40
Coal	6	
Coal	1½	40
Coal	¾	
Iron black band		3
Coal		
Interval		
Iron nodules	½	
Interval		
Coal	½	80
Iron ore	½	
Interval		
Coal	?	
Iron	¼	70
Iron (XII)	1	
Iron ore (XI)		5

Owen.

Iron ore nodules		
"Newell Coal"	5	
Coal	?	35
"Whitman Coal"	5	
White & pink S.S.		
Conglomerate		40
Slate black	12	
Coal	2	
Slate black		13
Iron black band		
Coal (Wilber)		
Slate		11
Coal	?	
Hard white S.S.		
Conglomeritic		41
Slaty		
Coal	4	
White S.S.	20	
Pink & green shale	20	
Yellow pebbly S.S.	20	
Sandstone and coal streaks	8	103
Thin S.S. / Heavy pebbly / Shale (XII)	40	
Iron ore (XI)		5

Needham.

Coal	2	
Brown sandstone	8	
Coal	5½	
White sandstone	?	
Slate black	12	
Coal	2	
Slate black	13	
Coal	1	
Slate black	10	
Coal	1¼	
Slate black	7	
Iron blackband		
Sandstone		
And pea		40
Conglomerate		
Slate		12
Iron nodules		
Coal	5	
Fire-clay	4	
Shales	11	
White S.S.	12	
Pink S.S.	14	
Conglomerate	15	
Iron	5	
Massive grey Sandstone (XII)		30
Iron ore (XI)	5	

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Blackband ore, so called, overlying the Wilber coals in Elk county Pennsylvania, gave to Dr. Owen the following analysis: Protox. iron 56.25 = 43.75 iron; carbonic acid 29.95; bituminous matter, loss, etc. 2.75, a percentage so small as to deprive the ore of its title to the name of black-band; silicates, lime, alumina, magnesia sulphur, 6.5 1 2 .75 .02 and water .08 of one per cent. The ore itself however is an uncommonly rich ore for the Coal measures, so far as its iron is concerned in this analysis. It is described however, as only one foot thick, with a few inches of very lean ore over it. Much has been said about the discovery of this black-band bed in northwestern Pennsylvania as though it were a matter of importance; but the analysis above given shows that the amount of bituminous matter is merely enough to blacken the ore stratum and give it the outward appearance without the peculiar qualities of the Scotch black-band; and this is true of many similar discoveries in other parts of the United States.

Near the bottom of the Lower Coal measures, that is, usually, within the first 75 feet above the Conglomerate, lies the large coal bed B, and in the shales above it is the first constant and extensive deposit of iron ore worthy of mention. On Broadtop it is a quasi black-band in two or three separate layers between which lies a small coal bed. At St. Mary's in Elk county where the coal B seems to be thin, the ore above it lies in oval blocks closely together in a thickness of from 2 to 4 feet, with ore balls scattered through the slates above, while 15 feet beneath it over the small coal A are also balls of grey carbonate.[4] The sections given a page or two back show these bands of ore on the waters of the Tunamaguont or Tuniangwant. On the Alleghany river the ore and coal are thus described in general terms.[5]

Shale, sometimes thickened with beds of sandstone; contains much nodular **iron ore;** at Alleghany furnace above Kittanning 9 layers in 12 feet; has yielded well at Scrubgrass and Rockland furnaces; [at Johnstown etc.] 20 to 40 feet.

Coal, B, good; 3½ feet at Leonards above Kittanning, over 3 feet fire-clay; 233 feet above the Alleghany at Robinson's salt works, nine miles below; opened frequently southeast of the Clarion; 5 feet thick west of the Alleghany, over which are three thin coals; ranges through Irwin and Sandy (Venango) 12 feet below the limestone, 3½ feet thick with a rider coal of 20 inches in the shale above; 30 feet

[4] Rogers's Final Report, vol. ii. p. 552.
[5] Lesley's Manual of Coal. Philadelphia: Lippincott & Co., 1857, pp. 109, 110.

below limestone at Lucinda furnace, Pinegrove (Clarion); at Mercer lies just under the limestone 3 feet thick; also at the mouth of Beaver river, 4 feet thick.

At Massillon in Ohio this bed of ore is two or three feet thick in solid plates nearly at the level of the river. In the west Kentucky coal region the ore is disseminated through shales in many small layers.[6]

Over the Coal B shales lies a massive sand rock, which on Broad Top in middle Pennsylvania is about 35 feet thick, and this rock seems to be as persistent in the west as the conglomerate beneath it. The Pennsylvania geologists gave it the name of the Tionista sandstone, because of its northern development along those waters analogous to that of the higher Mahoning sandstone in the region of the Monongahela in the southern. The fact was the identity of the rock was first enforced upon us by seeing it overspread that particular region. On the Neshannock river near the Ohio state line, this rock is about 60 feet above the conglomerate, and just under it is seen a bed of iron ore 6 inches thick with 2 feet of limestone and chert under it again. This limestone Mr. Rogers in his Final Report[7] chooses to call the Mahoning limestone, not from the small river of that name in southeast Pennsylvania, but from the river of that name which flows out from northwestern Ohio. On account of this confusion of places the term is unfortunate and will no doubt be dropped for some better one hereafter. Two miles below Newcastle the six feet of shales beneath the Tionista sandstone contain iron ore, and the horizon of this ore is preserved in many other places.

At a higher level than the Tionista sandstone is a large limestone formation coextensive with the uppermost water basin of the Ohio river, upon which rests the great ore-bearing shale formation of Armstrong, Butler, Clarion, Venango, Mercer and Lawrence counties in Pennsylvania and Trumbull and Mahoning counties in Ohio. These formations are sufficiently described in general terms by the following abstract of the annual reports of the Pennsylvania geologists, previous to 1842.[8]

Buhrstone Ore Shale; brown and black with nodules of carb. of iron and layers of sandstone, sometimes as a solid stratum 10 feet thick in the middle of the shales; thickness 25 feet.

Buhrstone and Ore; a bed of hard, grey, yellowish chert or flint store, cellular

[6] See Section of Owen, vol. iii. p. 12.

[7] Page 567, top of the page.

[8] Lesley's Coal Manual, page 112.

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and worm-eaten from the weathering out of iron and lime. The ore lies on the buhrstone and under the shales; is a brown peroxide at the outcrop, and protocarbonate under cover. Where the chert abounds the ore is lean; when the shales above are free from sandstone the ore is thick and good. [Both chert and ore are deposits subsequent to the deposition of the shale which contained them, but previous to the denudation of the country; for the ore occurs sometimes as thick at the outcrop as where it has the full deposit of shale above it. The leaching process which carried off the iron and silex disseminated through the shales down upon the face of the calcareous mud must have found the latter an unbroken impervious plane, and not, as now, rent in fissures through which the waters find their way with such ease that gangways in the ore are always dry. This is another datum we have for calculating the date of the Denudation. It is this leaching process which has converted the carbonate into the oxide and thus enhanced the theoretical percentage of iron in the ore from 46 to 56 per cent. An analysis of a specimen from Armstrong county is given in the 4th annual report to this effect:—Iron 32.95, carbonate of iron 68.32, carbonate of lime 15.54, insoluble (mud and sand) 10.58, water 4, carb. mang. 1.35, traces of magn. and mang. Another specimen gave:—Iron 25.34, carbonate of iron 54.33, insoluble 40.90, water 4, lime, magn., alum, traces. Another from Warne's, on Bennett's Branch, Clearfield county, gave:—Iron 34.72, carbonate of iron 55.10, peroxide of iron 9.50, carbonate of lime 5.80, carbonate magnesia 5.40, insoluble (sand and mud) 21, water 3. There remain in the shales above the ore plate usually a vast number of nodules of carbonate of iron, more or less mixed with silex and lime, and these are often in sufficient proximity to admit of mining with the ore. In places it is beautifully variegated with the disks of encrinites crystallized white upon a blue and purple ground, and sometimes the iron itself is crystalloid. Its surfaces are frequently mammillary.

The ore bed proper varies from an inch to 5 feet, rapidly changing its form, composition and thickness at every step. It yields best wherever there is a bowl in the limestone. In the openings two miles south of Shippensville in Clarion county, it has reached 9 feet, throughout which the silex is disseminated. [Its best average may be stated at less than 18, and a common average over large areas at 10 inches.]

Fossiliferous Limestone, c, compact, light, blue, disposed to weather into thin layers, but very hard, sometimes slaty, always interrupted vertically by silicious beds, burns grey, abounds in *encrinal disks* of crystallized carbonate of lime, innumerable small shells (*terebratulæ*) with occasional sharks' teeth. It varies from 10 to 20 feet, and has a very wide known range.

It rises from beneath the Alleghany river about 4 miles above the mouth of the Kiskiminetas (where it is 100 feet under water), and slowly ascends the river and the hill-sides together, outcropping on all the tributary valleys and finally throwing its waving outcrop across the highland in ranges of low summits covered with chestnut and oak and distinguishable from a great distance in a landscape filled with hemlocks and pines. These knobs cross through Pinegrove, Elk creek, and Irvine townships in Venango. At Kittanning it is 100 feet above the river; and several hundred at the mouth of Bear creek; it occurs on Red bank east of N. Bethlehem, and ascends both sides of Clarion [and has been traced through Elk county into McKean along the centre of the 4th basin. It is recognizable as far east at least as Karthaus and Clearfield; and southeast throughout Indiana, Westmoreland, Cambria and Somerset into Virginia. It is not everywhere accompanied by the buhrstone, but almost always has over it traces of the ore more or less remarkable. Throughout

the south and east it scarcely can be said to exceed 4 feet, and seldom shows any peroxide except at the crop.] West of Kittanning on Buffalo creek it is 15 feet thick; it comes within 10 miles of Franklin, and shows itself on Bear and Sugar creeks; emerging on Slippery rock and Beaver river it is 20 feet thick, etc.

The buhrstone of the Clarion is compact, grey outside, light blue within, and covers the surface of the country with fragments from 3 to 12 inches in diameter. The limestone cannot always be traced easily because when the beds are thin they readily decompose, and has formed no visible terrace along the hill sides.[9] The ore varies much, being sometimes a solid, hard, blue fossiliferous stratum, like limestone, and at other times a layer of crusts or shells formed concentrically about a nucleus, the nodules being often as much as 7 inches in diameter, the nucleus yellow, surrounded by a hard black crust a quarter of an inch thick. The chief part of the ore consists of these crusts, like fragments of larger masses, and very frangible. When broken there often flows out a dark unctuous fluid. The inside lining is a smooth, glossy black, or covered with minute yellow, purple and violet-colored crystals, commonest next the chert. In the upper part of the ore layer the yellow clay abounds. Between the ore and the limestone lies the chert, passing sometimes into the one and sometimes into the other.[1] The ore upon the Coneconessing attains a thickness of 5 feet, and lies in the hollows of the limestone's upper surface, without chert. The limestone itself is fissured widely and deeply; but as the ore bridges these fissures and is thickest in the hollows of the limestone, it is reasonable to conclude that it was deposited at a comparatively early date, perhaps immediately before the consolidation of the shales at the bottom of which it lies, and before the elevation of the coal measures into the air gave the drainage waters opportunity to widen the natural cleavage joints of the subjacent limestone to the size of the present fissures. Listening at the outcrop of the ore, one can hear the waters which drain through the shales above the ore and through the ore itself, falling in tiny cataracts down through the unseen fissures ten or twenty feet. If *these* were the waters which produced the ore, why has the ore bed itself not been all swept away long before this? It is likely then that the ore was deposited with the shales and immediately sought their lowest level against the upper surface of the previously-deposited limestone.

[9] F. R. p. 568. [1] Final Report, p. 569.

Beneath the ferriferous limestone in **Pennsylvania,** and beneath the place where it should be in western Kentucky[2] is an under layer of ore. In Clarion county Pennsylvania, the author found in 1841 when he traced this bed,[3] that this lower ore had been struck in Lowrie's well at Strattonville, six feet beneath the limestone. On the Alleghany river at Brady's bend and further west the same ore is seen in the same place.—This ore must not be confounded with local deposits in shale, still lower in the system; for under the limestone, with an interval of 15 or 20 feet (*e. g.* at Scull's run) comes the Clarion coal, under which are numerous beds of ore in about 40 feet of brown shale. At least four beds of this ore are named, the uppermost—1. Roll ore, in masses 2 to 3 feet long and 8 to 12 inches thick, coarse; 2. Pig ore, in cylindrical nodules from 6 to 24 inches long; 3, small nodular ore; 4, Flag ore, in flags from 6 to 20 inches broad, scaling off in conchoidal crusts.[4]—Near Curlsville the limestone 4 feet thick rests on sandy shales 15 or 20 feet thick at the bottom of which are 8 to 14 inches of good fusible nodular ore in a single bed, opened on the west side of the river.[5]—In the Sugar Creek section, where the upper ore is 12 feet above the top of the limestone, this lower ore (4 to 10 inches thick) immediately underlies it.[6] It forms the main dependence of the Great Western furnaces, 2 miles up Sugar creek, and is called their "summit vein." It averages from 2 to 2½ feet, but is 4 feet thick in Phillips' hill. It yields 30 per cent of metal. Over it is a stratum of fire-clay making good fire-brick and it is used in preference to the fire-clay under the Kittanning coal bed. Sometimes the ore sinks below the limestone some feet, and when the interval is filled with sandy shales then the buhrstone appears in the ore, but when it lies close up to the limestone it is calcareous and shaly. Sometimes it is highly bituminous and sulphurous. Its average yield is 35 to 37 per cent metal.[7] By this we see that the limestone has nothing to do with the ore *as a flooring.* Two miles south of Armstrong's mills in the Red bank creek country this ore, of fine quality and some inches thick, underlies a black slate 2 feet

[2] Owen, Report, vol. iii. p. 11.

[3] Final Report, vol. ii. p. 570.

[4] Final Report, p. 571; there is some error in the original text.

[5] Final Report, p. 572.

[6] Final Report, page 577.

[7] Final Report, p. 578, vol. ii.

thick. One mile below Troy the ore is in the lower part of 30 feet of shales under the limestone (4 feet) over which is the oölitic (buhrstone ore) in shales. At Reynolds' and Shank's furnace, on Red bank, the grey limestone 6 feet thick has the ore *over it* from 0 to 3 feet thick, and *under it* 9 inches of equally good and more regular ore, without chert.

The buhrstone ore at the Deal bank, 2 miles south of Shippensville has been extensively wrought and is from 4 to 6 feet thick, exceedingly variable. The chert comes out in pieces from 4 to 10 inches square and is abundant in the *upper* part of the ore bed. The *ore bed is separated from the limestone by several feet of greenish slaty sandstone.*—At Curlsville, on Licking creek, half way between Clarion and the mouth of Red bank, the buhr is finely developed in the lowland. Here the limestone is but 4 feet thick. In contrast to its thickness here, it is 15 feet thick in the country west of the Alleghany river between Franklin and Warren; but there *it has neither buhrstone nor ore.* Through the northern part of Butler county it carries chert, but seldom ore. Within four miles of Centreville the ore comes in from 6 to 20 inches thick, *and is sometimes wholly replaced* by a foot of buhrstone, resting immediately upon the limestone. At Buchanan's, 2 miles from the village, both together are but 8 inches thick and a bed of clay separates them from the limestone. The limestone seen 7 or 8 miles south of Mercer is on the outcrop line which runs straight past the mouth of the Little Neshamock on to Newcastle. The country to the south has plenty of coal and limestone but little of the ore, until we descend the Coneconessing and Mahoning rivers to near their junction where the ore is extensively mined between the two streams, and is from 2 to 5 feet thick.

In the Sugar creek section[8] over the ferriferous limestone (15 feet thick) lie 12 feet of sandy shales and over them a "slab vein" of silicious ore 20 inches thick, over which lie 40 feet more of clay sandstone with nodules.

On Crooked creek the limestone 6 feet thick is full of bivalves but shows no ore. At Kittanning it is 15 to 25 feet thick and 70 feet above the bridge and shows some mottled ore over it. At Alleghany furnace the limestone, a grey blue rock with a few fossils, supports from 5 inches to 4 feet of ore; occasionally

[8] Final Report, p. 577, vol. ii.

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6 to 8 inches of yellowish chert is interposed, occurring in patches 8 or 10 yards square. The lowest limestone layer (4 to 10 inches thick) is enough of an ore to be mixed to advantage, and six or more nodular beds run through the shales below. At Buffalo creek furnace the ore over the (15-feet blue solid) limestone has very little chert. Along the Kishiminetas about Warren the limestone is 7 feet thick but has no ore over it.

The Limestone next higher in the series and connected with the Freeport coals, is in itself at some places a very ferruginous stratum. At Punxatawny on the borders of Indiana county it is half carbonate of lime, half carbonate of iron, 3½ feet thick. Further down the Mahoning creek it has shales above it from which fall masses of honeycomb ore. Sometimes nearly pure layers of carbonate of iron an inch or two thick accompany the limestone. At Ewing's mill further down, a very pure bed of block ore 18 inches thick in layers of 4 or 5 inches with concretions of silica, while masses of veins of pure carbonate of lime seem to subdivide the bed, has been referred to the same but may represent the lower ore.—Nearer the Alleghany river at Alleghany furnace a bed of ore one foot thick forms the floor of the Lower Freeport limestone. Two or three miles below Kittanning the ore under this fine grain, light blue or dove-colored limestone (10 feet thick) is 6 to 12 inches thick.—At Winfield furnace west of the Alleghany, the ores relied on are from the brown calcareous ore bed sometimes 4 feet thick in the fire-clay under the Upper Freeport coal. At Leechburg 3 inches of iron ore overlies the Freeport limestone (1 foot). Here the Freeport sandstone (a fine quartz conglomerate) is seen at the water's edge to contain a nearly solid stratum of ore balls 10 inches thick.

On the Ohio river below the mouth of the Beaver river, below Philipsburg village, the ferriferous limestone is just below water level, covered with slaty sandstone and brown shale over which comes the Kittanning coal, over which are ferriferous shales. No buhrstone ore is known in this region. At Two-mile run the limestone is 20 feet thick and rises westward through all that country without the ore.

In northeastern Ohio three furnaces were running in 1838, one at the mouth of Musquito creek, one near the mouth

of Mill creek, and one on Yellow creek, making castings chiefly and getting coal measure ores with some difficulty. The Akron and Middleburg furnaces were supplied from southern mines, having ceased to rely upon the precarious and expensive supplies from beds in the vicinity. The deposits of bog ores are too limited and uncertain to be made the basis of iron manufacture.[9] The large introduction of Lake Superior and Lake Champlain ores of late years, shows not only their adaptation to make superior iron by mixing, but also the difficulties attending a constant supply of first class coal measure carbonate and their outcrop hematite ores. The black-band around Youngstown furnishes its quota to the usual mixture, but cannot be relied upon to stock the furnaces even if it were desirable to use it alone. An enormous quantity of iron ore in carbonate nodules lies forever bedded in the shales above and below the conglomerate base of the coal measures, too scattered and uncertain to be mined. The most important beds known in 1838 were that already mentioned, and those in the black shales of Mill creek below Youngstown furnace, 4 to 8 inches thick; on Dry creek 3 miles east; and on Yellow creek. But where the shales are cut down by ravines, the sections expose but two or three feet of ore in a hundred,[1] and so distributed in two and three-inch layers as to be inaccessible. Poland furnace was supplied from pieces gathered in the bed of Yellow creek. The present large and prosperous stacks on the Mahoning use one-half Lake Superior or lake Champlain ore and the rest mixed nodular and black-band. There has been lately found near Massillon a bed of carbonate apparently one or two feet thick just under the river bottom which if followed up and mixed with lake ore may keep the Tuscarawas stacks going for many years.

* On the **Mahoning** river in Ohio, the **Mahoning** furnace (H 457) uses raw bituminous coal to smelt a mixed burden of ½ *blue plate carbonate* ore from a bed 6 to 10 inches thick lying 15 feet above the Mount Nebo [1] coal vein in the hills of the neighborhood ;—¼ Lake Superior ore and—¼ rolling mill cinder. The Lake Superior ore alone was found not so good for mill iron. Hence all the ore of one kind is roasted separately and the mixing is done at the foot of the water-hoist. The Mount Nebo coal bed which is the same as the Briar hill, and Mathersfield coal bed, lies about 50 feet above water level at Mount Nebo but is supposed to be beneath water level at Lowell (Mahoning furnace). Two other small coal beds exist in the

[9] Whittlesea in Mather, 1838, p. 67. [1] Whittlesea, p. 66.

hillsides above the furnace; and on the hilltops. say 200 feet up, lies the great fossiliferous white limestone 20 feet thick, full of large encrinal joints and shells.—**Falcon** and **Phœnix** furnaces use the same mixed ores, only that ¼ black-band ore is added, from a layer 4 to 8 inches thick immediately underlying the Ward bank coal, seven miles southwest of Briarhill.—**Eagle** or Philpot furnace uses black-band mixed with a Canadian primary ore from Byetown, a dirty ore containing masses of plumbago as big as one's fist and streams of gneissic quartz. Cakes of copper are left in the hearth on blowing out. The rolling-mill metal made is good.—**Briarhill** furnace mixes ¼ Ward's black-band, ¼ mill cinder, ¼ Canada ore and ¼ rock or kidney carbonate from the hill-sides. The coal of all these furnaces, used raw, comes from the cannel coal bed, which strangely enough makes a worthless *cold-short* iron with the same Coneconessing brown hematite with which charcoal makes best mill-metal.—**Meander** furnace was built in 1858 in the immediate neighborhood of Ward's black-band ore, but mixes it ¼ with ¼ Lake Superior ore, and ½ native kidney or plate silicious and argillaceous blue carbonate. The coal used is from a higher bed than the Mount Nebo.—The abandoned Musquito creek furnace used bog ore.—**Volcano** at Massillon gets its shell and kidney ore from 25 miles south by canal, and mixes Lake Superior.[2]

N. E. Ohio.

In **Tuscarawas county** eastern Ohio, the Zoar and Fairfield furnaces were the only ones built in 1837 when Mr. Briggs reported to Prof. Mather principal, geologist of that state survey. Their ores however helped to supply the Granville furnace in Licking county to the southwest and the Massillon and Akron furnaces to the north. These ores overlaid the buhrstone horizon so far as it was known in this intermediate part of its range, and consisted of nodules in slate, compact and blue within, yellow and shelly outside and falling to pieces in concentric shells when exposed to air or roasted in the heap; hence the local term "shell ore," still in use. The lower beds range extensively through townships 9 and 10, R. 2 and 10, R. 1. The upper beds mined and used at Fairfield, Tp. 9, R. 1, shows a face of working from 3 to 12 feet and in one case 15 feet of impure ore, oxide of iron and dark shale, yielding 15 to 20 per cent of iron and easily smelted. A mile or two south of Dover a stratum three or four feet thick was struck. An excellent ore a foot thick appears in the bank of the Tuscarawas two or three miles above New Philadelphia. Large quantities of iron ore of good quality appear upon the outcrop slopes in many places, but this mineral wealth must still wait for the perfect organization of the coke or raw-coal process of smelting iron in Ohio.

Big ore bed kidney ore Jackson county Ohio, near Jackson furnace, yielded iron 48.75, oxygen 20.89, water 12.79, earths 16.15, etc. containing probably a little sulphuret of zinc. Ore bed 6 feet thick, reddish brown, concentric nodules, hollow or

[2] Bulletin Amer. Iron Asso. 1855.

filled with clay, fracture fine uneven earthy dull. Place 70 to 80 feet above the Crookham seam, which is 70 or 80 feet above the conglomerate base of the coal measures The thin Henry seam and above it two block ore beds occur in the latter interval.[3]

The Ohio Buhrstone ore is placed by Foster in his section from Columbus through Zanesville in Mather's Report of 1838, about 200 feet above the Brownsville or lowest coal bed on that western outcrop of the measures, in Muskingum, Licking and Franklin counties of Ohio, but in the text its place is said to be 100 feet above the conglomerate. Buhrstone ore, Jackson county Ohio, near Radcliff's, yielded iron 58.626, oxygen 24.802, water 13.25, earth 1.508, etc. Ore compact, porous, brown, specific gravity 3.09.

The **coal measure ores of Muskingum county** Ohio, described by Foster in Mather's Report of 1838,[4] and divided into argillaceous, calcareous and silicious, with brown oxide at the outcrop, occur usually as nodules in shale, and contain often small quantities of lead, zinc,[5] manganese, crystallized carbonate of lime, sulphate of barytes and impressions of ferns; when exposed to the air, lose carbonic acid, absorb oxygen and peel off in concentric layers. The best beds lie in the lower coal measures between the conglomerate and the buhrstone, a hundred feet above it. At Dillon's furnace (centre of Falls township) three of the four beds were worked, two of which are seen at Zanesville near the water's edge, and the section at the furnace reads thus, descending the hill-sides:

Nodular iron ore (found also at Zanesville) . .	4.0 ft.
Sandst. 10, limest. 4, coal 1, slaty sandst. and clay 80	=95.0 "
Iron ore (Zanesville also)	1.0 "
Hornstone 0.5, cannel coal 2.5, sandstone 40 . .	43.0 "
Iron ore rich argillaceous extensively used . .	2.0 "
Sandstone and shale	30.0 "
Iron ore calcareous, used as flux	1.0 "
Sandstone	30.5 "
Bed of Licking creek ; whole height . . .	206.5 "

The same beds were used for Granville and Mary Ann furnaces in Licking county Ohio, and their outcrops range north-northeast through the western townships of Muskingum, indented by all the valleys and ravines, because of the exceeding gentleness of the dip eastward into the great body of the coal field under which, as the lowest of the coal measures, they sink

[3] Mather 1838, p. 39.

[4] Page 88.

[5] Almost every nodule in the bed at Zanesville, 20 feet above the level of the Muskingum river contains calc spar and zinc.

and pass beneath Wheeling and Pittsburg to reappear in western Virginia and western Pennsylvania, as already described.

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The sulphurous pyrites of iron is confined chiefly to the coal beds and the shales or slates between, in which it appears (as in the canal at Zanesville) in great cannon balls, and also disseminated in fine yellow crystals through the limestones.

The **buhrstone** which in northwest Pennsylvania is deposited together with the finest iron ore of that region at the base of ferruginous shales and upon the great fossiliferous limestone of the lower coal measures, is here in southern Ohio a separate deposit; see the following section got by Foster in Hopewell township Licking county Ohio:

Buhrstone, grey or yellowish-white, or greenish,	4.0 feet.
Shale 10; Hornstone 1.4; Grey Cherty Limestone 5; Shale dark 30; light blue 10; coal 0-8; slate sandstone 8; yellow shale 15;	=80.0
Iron ore, of good quality;	0.8 feet.
Shale dark;	10.0
Iron ore, of good quality, from one to . .	4.0 feet.
Limestone brown 5; blue 6; compact sandstone 40;	51.0
Whole section, ...	157.0

The Buhrstone passes into hornstone and becomes translucent; contains numerous cavities like amygdaloidal trap, some of which are moulds of infusoria; contains in its fractures drusy quartz, six-sided and smoky crystals; masses of chalcedony crystals in the cavities; rhombic pearly calcspar prisms and heavy spar or sulphate of barytes; terebratulæ, encrini, spirifer, productus, anthophylla and infusoria; and a trilobite was found in the underlying limestone on Flint ridge. Its range is near the Muskingum and Licking county line and marks of course the range of the iron ores beneath it.[6] It will be observed also that the buhrstone repeats itself as hornstone as if the deposit was due to *intermittent* hot springs.

The following condensed description of this part of the Ohio coal formation was made for the author's Manual of Coal, page 109:—

[6] Foster, in Mather, 1830, p. 92. See also Hildreth's description of the Buhrstone in the First Annual Report of the Ohio survey.

7. **Coal**, good 2 feet thick. **Upper part of Lower Coal measures.**

6. *Shale*, bituminous; containing nodular ore. Upper part slaty, smooth sandstone, in the interval, ... 15 feet.

5. **Coal**, slaty, 2 feet. Poor, light, cakes readily; near Zanesville 3 feet, eight miles above McConnelsville 20 inches. ☞ This is the locality of all the measurements from the fourth fossiliferous limestone to the calcareous silicious rock, ...

4. *Shale*, slaty clay, light ash color; *fire-clay* above, ... 15 "

3. *Sandstone*, coarse, loose, brown, crumbling, giving the sand beds to the Raccoon waters; seen well over the Buhrstone at Wild Cat's Den, section 26, Elk township; more slaty on Muskingum; silicious on Hocking, 20 "

2. **Iron Ore.** Thin, brown, oxide, porous, mammillary cavities, . . ½ foot.

1. **Buhrstone** 9 feet. "Calcareo-silicious deposit;" of uniform texture; pure quartz; free from lime and oxide of iron; light grey; cellular; sound metallic; intensely hard; stratified and regularly cleft; the bed plane most cellular and used as the face of the millstone; more or less marine shells; interpolated layers of limestone 2 or more feet thick above and below the buhr, which in such cases is but 2 to 4 feet thick; greatest thickness in any one bed 9 feet. The best Paris blue buhrstone, six and a half feet in diameter, sold in Cuvier's day for $240. The Ohio buhr was first wrought by Abram Neisby in 1807, and during the embargo superseded the French. From 1814 to 1820, 4½ feet stones sold for $370 a pair, 7 feet for $500; in 1834 four feet stones for $150. The rock is a mine of wealth to Richland, Elk, and Clinton townships, and Hopewell township Muskingum. It ranges from the Ohio river to Stark county and on northeastward, in a band from 12 to 20 miles wide with an easterly dip. At Toppin's mill, Margaret county, 6 feet exposed, layers of 6 inches, grey, calcareous, splits smooth into window sills, etc.—Beds the streams in Lee township, roof loose sandstone, floor dark shale. Further west a bed of coal occurs a few feet under it; still further west *it rests on coal.*—At Judge Warner's, Lee township, in road, 8 feet thick, strata 8–10 inches, upper layers calcareous, lower pure quartz and hornstone; black, green, blue, horn color; fracture conchoidal; lowest layer nearly black; top layers cellular; *this feature seems confined to its western outcrop.*—Seldom seen large until Elk township 24 miles southwest of Athens, where are many quarries.—Crops out on the highest hills of Richland township (Jackson) 8 miles west of McArthurstown. At Redfearn's east branch mid fork of Salt, a conglomerate of water-worn quartz pebbles cemented with sand and iron, covers the hills to the base with its fragments;—traced north to Raccoon creek heads and Honey fork of Queer (Hocking);—southward rich buhr quarries in a belt 12–14 miles wide, 6–8 broad.—Middle of Wilkes township (Gallia) crops under the bridge 4 miles west of Wilkesville; appears no more to the eastward; cut in salt wells on Leading and Chickamoga creeks Southwest it crosses west end of Gallia county, head of Symmes' creek, to Ohio river.—Northeast from Jackson county crops out east side of Hocking county and York township Athens county 8–9 feet thick, roof coarse sandstone. East of Hockhocking river, few fragments of it have survived weathering; northeast corner of Green township and in Monday creek township seen in place; abundant in Perry county; continuous on Rush creek Pike township Lexington, a pure quartz, used by the Indians for arrow heads; bears northeast into the corners of Licking and Muskingum counties, forming the "Flint Ridge" summits; in both Hopewell townships it covers the surface with fragments; used by Indians for knives and spears; innumerable pits from Jackson to Muskingum.—In Muskingum color is lighter; no open fissures, but full of tortu-

ous vermiform passages, one sixteenth of an inch in diameter, the matrices of a fusiform univalve, and encrinal joints, with some terebratulæ, spiriferi, producti, etc. 8–9 feet thick.—From Hopewell to mouth of Licking dips 10 feet to the mile.—South along the Moxahala creek lies high on the hills, yellow, soft, full of terebratulæ; in York township (Morgan) 8–9 feet thick; traced down Island and Oil Runs to Muskingum river, and goes under 2 miles above McConnelsville.—At McConnelsville bored through 110 feet below water, *the lower or main salt rock lying* 650 *feet below it, with little variation, for* 10 *to* 12 *miles below.*—At Campbell's mills 10 feet, floor bituminous shale; some of it pure conchoidal limestone. **E. Ohio.**

In **Perry, Athens and Hocking, Jackson, Lawrence and Scioto counties of Southern Ohio** the ore beds on which their numerous furnaces depend for stock are principally between the buhrstone and the conglomerate, but are of very different qualities, some being soft and others hard, some calcareous and others silicious. That which lies upon a limestone resembles the ore of northwest Pennsylvania in the same position. Hildreth described it in one place near Hazeltine's mills in the southeast corner of Perry county as filling several feet of a thick ochreous deposit of slaty clay upon buff limestone, as a rich argillaceous heavy ore coming out in tabular masses one foot thick. Brigg describes other such localities south of this,[7] in one of which (section 7 Green township Hocking county) a second bed of ore 10 inches thick overlies a white sandrock over the shales above the limestone ore. Crook's, Green's and Wright's banks are all in Hocking county, the last in Star township sec. 26, T. 12, R. 16, a 3½ feet thick mixture of ochre and solid ore. In Athens county the most continuous deposit is a heavy, compact, bluish band a few feet below the Nelsonville coal and 6 to 10 inches thick, containing impressions of ferns, at Whittemore's on Snow Fork Monday creek, and up the creek. It runs along the Raccoon creek waters, coming out in large plates containing fossil plants.[8]

In his report to the Central Ohio Coal and Iron Company in 1856, Dr. Hayes speaks of the ores of Perry county as "not the clay iron stones of the bituminous coal measures such as are found in England, but in percentage of iron they closely approach the magnetic oxides of the primary rocks, but can be more easily smelted; they generally will contain, mixed with flux, the proportion of iron which reduces with the greatest

[7] Mather, 1838, p. 142. [8] Briggs in Mather, 1838, p. 144.

economy to grey iron; they all contain traces of manganese oxide, but in no case is enough present to give character to the iron." To avoid misunderstanding these expressions, it is only necessary to remark that the specimens sent to Dr. Hayes were of course from the peroxidized outcrop; for the beds *are* the clay iron stone beds of the English bituminous coal measures and no other; and in no common sense, except as subjects of analysis, do they resemble geologically the magnetic oxides of the primary rocks. The opinion of Dr. Hayes is therefore all the more valuable, as being a purely analytical and chemical one, in its bearing upon the probable sedimentary, perhaps carbonated sedimentary origin of the primary magnetic ores; while it so far forth sustains the chemical cycle of metamorphosis so frequently alluded to in the preceding pages.

These Perry and Hocking county Ohio ores are situated in Salt lick and Monday creek townships, but they are common to the belt of rocks crossing these townships and the Ohio river. The Straitsville coal bed 6 feet thick, dipping southeastward 30 feet in the mile, outcrops on each side of the proposed Straitsville Branch railroad to within 5 miles of the Scioto and Hocking valley railroad. A few inches under it is a bed of ore reported by Mather to be from 10 to 16 inches thick. Another, not proved, lies 50 feet above. The limestone ore, from 8 to 16 inches thick, lies far below. Dr. Hayes's specimens are not so named as to determine certainly to which of these beds they belong, but they are all evidently from the outcrops:

	Peroxide of iron.	Carbonate of lime.	Earthy residuum.	Water and carbonic acid.
1 Ball	64.20	.40	6.60	28.60
2 Kidney	61.20	1.20	9.80	27.50
3 Hydrate	76.70	1.20	7.80	14.00
4 Hydrate	83.20	.40	5.40	10.80
5 Slaty	40.40	.80	49.80	8.80
6 Black	84.20	1.40	4.20	10.00

No. 5 is marked "ore above cannel coal at tunnel," and described as coming out in laminated masses, nearly white externally, yellow and brown within, soft, fragile, a mere ferruginous slate decomposed. Many of the slates and shales of the coal measures are heavily charged with carbonate of iron, apparently in the condition of uniform distribution, and sometimes concreted into nodules; but the nodular form seems to have been assumed only in those comparatively loose and fluid muds

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which allowed free movement to the iron. The sixth specimen is described as derived from a grey carbonate of iron; for in its altered state it presents yellow and brown oxides with grey carbonate. After roasting, 100 parts contain 93 peroxide = 65 pig iron. It is free from sulphur.

In Kentucky the best ores hitherto collected, says Owen in his second volume (1857), page 68, have been found in the Lower Coal measures; there is however some excellent blackband ore high up in the Upper measures of Muhlenburg county, but so far as we have seen only six inches thick; and there appears to be a considerable quantity of iron stones in the Upper Coal measures in the shaly beds lying some distance under the Bonharbour Coal.[9] Of these blackband ores Mr. Lyon in his "Observations on Hopkins, Crittenden, Livingston, Caldwell, Christian and Henderson counties,"[1] says that all the localities on Cane run, Stuart's, Richland and Flat creeks are doubtless the outcrop of the same bed. "The differences to be found in sections taken of this bed at a distance of three or four miles asunder are not greater than of those at the same outcrop within a few feet of each other." He gives the following section, made on the head waters of Stuart's creek, as typical of the constitution of the bed:

Black bituminous shale in inches	6	.	1	.	3	.	3	.	2	.	6 .
Black-band ore "		.	1	.	1	.	1	.	1	.	2 . .
Bluish (fire) clay under all		.	.	.	.	.	.	.	.	.	. 12+

by which it appears that the aggregate of shale layers amounts to 21 and of ore layers to 6 inches. Mr. Lyon thinks that the *average* of many localities may be set down at 8 inches. Under the fire-clay are evidences of a bed of limestone.

The eastern coal field is vastly rich in iron stones, especially towards its base, in Greenup and Carter counties. Fifty-eight (58) ores have been analyzed from Greenup county, and six from Carter; also thirteen different specimens of pig iron, produced from these ores, and fifteen furnace slags. These ores are all interstratified as beds conformable to the associated coal measures. Their relative position is well illustrated by local sections, obtained at the ore banks of the Sandy, Mt. Savage, Star, Bellefonte, Pennsylvania and Amanda Furnaces, which will be found in the second chapter, under the head of Greenup county (See Diagram No. 3.)

[9] He also speaks of a specimen sent from somewhere near Irwin, Estelle county, which was found to contain 21.13 per cent copper.

[1] Owen, Vol. ii. p. 339.

The beds vary from three inches to four or five feet. They belong, mineralogically, to the family of limonites, or hydrated oxides, and protocarbonates of iron, yielding from twenty-seven to sixty per cent of metallic iron. They lie usually on or between shaly beds, sometimes resting on or overlaid by limestone. These associated limestones are often highly ferruginous, yielding from seven as high as twenty-five per cent of metallic iron, therefore well adapted for fluxes for the iron ores, when free from pyrites or other injurious principles, since they not only supply the lime necessary to produce, with the earthy ingredients, the proper cinder or furnace slags, but contribute largely to the iron product.

The chemical analysis of certain ores discarded as impracticable, especially of Nos. 36, 37 and 38, prove that their impracticability does not arise from the presence of unusual quantities of injurious elements, such as sulphur, phosphorus, arsenic, or zinc, since they contain but a trace of sulphur, 0 15 per cent being the largest amount of that substance estimated in any of them, and 0.3 per cent of phosphorus, while no appreciable quantity of either arsenic or zinc was detected. Indeed it seems that the difficulties which have been encountered in reducing these ores arise from their very richness, containing. as they do, from sixty and nine-tenths (60.9) to thirty-nine and four-tenths (39.4) per cent of metallic iron, and only from 3.47 to 9.47 of insoluble silicates, while ores highly esteemed contain but twenty-nine (29) per cent of iron, and forty-five (45) per cent of insoluble silicates. It appears, therefore, that all that is necessary to render these ores available is the addition of earthy matter, either by mixing them with lean ores, so as to reduce the percentage of iron, and increase the quantity of silicious earths, or to introduce. with the rich ore, a certain quantity of ferruginous shale to the furnace burden. As this material is abundant throughout the iron region of Greenup county, often constituting the stripping of the ore banks, it can be easily obtained and applied for this purpose, where suitable mixtures of lean ores cannot be had The object to be obtained by these corrections is to insure the formation of a fluid slag or lava, that will flow freely, eliminate completely the metal, admit of its free carbonization, and thus increase the fusibility of the pig iron. Furnace slag being the index to the quality of the iron simultaneously produced. I selected, during my geological reconnoissance of Greenup county, various specimens of these glassy scoriæ from different iron works, with special reference to the quality of the cast iron flowing from the furnace at the time of their production. The general results obtained by their chemical examination are as follows: The principal constituents are silica, lime and alumina. with small quantities of magnesia, potash, soda, and sometimes protoxide of iron and manganese. The normal quantity of silica is about fifty-six (56), lime twenty (20), alumina fifteen and five-tenths (15.5), other bases eight and five-tenths (8.5) per cent. The silica ranges from about fifty (50) to sixty (60) per cent; the lime from thirteen (13) to twenty-seven (27); the alumina from eleven and five-tenths (11.5) to twenty (20); the other bases from five to eleven.

The glassy slags having, usually, *a smoky purple color*, produced when the furnace is making soft grey iron, contain very nearly the average or normal quantity of silica—fifty-six (56) per cent—with generally nearly the largest amount of lime. The *opaque pea-green slag*, No. 86, produced at the Raccoon furnace, contains the largest amount of silica, sixty-one (61) per cent. This was the least fusible of all the slags operated on, and contained very nearly three per cent of protoxide of iron. The *white pumiciform slag* contains the smallest quantity of silica, and the largest quantity of lime, and is the most fusible of all. Its extreme lightness and cellular structure are no doubt attributable to its fusibility, and the tendency which the

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excess of lime has to remove sulphur and phosphorus, which, being disengaged suddenly in the form of sulphuretted and phosphuretted hydrogen, in the midst of or underneath this fusible slag, puffs it up into the porous white cinder, which is not only remarkable for its extreme whiteness and lightness, but for the length of time it continues to disengage sulphuretted hydrogen, with a crackling sound, even for months after its removal from the furnace. This pumiciform slag has very nearly the same chemical constitution as the *anhydrous prehnite*, analyzed by Jackson and Whitney. The lime in this slag is considerably more than is required to flux the earthy ingredients; if the ore has a considerable amount of sulphur or phosphorus, then the predominance of lime may, perhaps, be found advantageous in removing the excess of these elements.

The pea-green slag, No. 66, contains six per cent of protoxide of iron, equivalent to four and six-tenths (4.6) per cent of metallic iron; the largest amount of iron in any of the slags analyzed. This loss of iron might be avoided, in part at least, by increasing the amount of lime about three per cent to replace the protoxide of iron. No. 52 contains the largest quantity of alumina. This is no doubt to be accounted for from the fact that the carbonate of iron—"grey limestone ore," No. 49, worked at the Bellefonte furnace, where this slag was obtained—contains a larger quantity of alumina than any of the ores from which the slags analyzed have been derived. It does not appear, however, that the pig-iron from this furnace contains more than the average quantity of alumina. It is important to remark, that though the quantity of lime, alumina, and other bases, are liable to some little variation, even in the best slags—Nos. 40, 64, 65, 85, and 110—yet they all possess this chemical relation in common, as is shown by Dr. Peter's Report, that the quantity of oxygen in these bases is, within a fraction of a per cent, one half the oxygen contained in the associated silica or silicic acid; in other words, *all these slags are bi-silicates*, proving that there is no better mode of ascertaining whether the ore and flux are duly proportioned in the burden of the furnace, than by a chemical analysis of the slag. The pea-green slag, No. 112, produced at the New Hampshire furnace, preserves this normal *proportion* of oxygen in the bases and silica, though it produces a pig-iron of rather closer texture than usual; this may, perhaps, be accounted for from the manganese, which is nearly three per cent, or over two per cent, above the average quantity, and about one and a half per cent more than in any other slag on the analyzed list. This is no doubt derived from the very dark-brown red limonite ore, No. 106, worked at the New Hampshire furnace, which contains 2.15 per cent oxide of manganese, being the largest proportion of that oxide present in any of the ores analyzed, except No. 44, the "Black vein," of the Buena Vista ore banks, which has 2.92; No. 57, the dark-brown red "Little Block ore," of the Buffalo ore banks, which has 3.15; No. 119, the top hill ore of the Clinton furnace, which has 2.17; and No. 11, Wallace's iron ore, from near the Falls of Blain, which has 3.41. It would require, however, a greater number of comparative analyses of ores, pig-iron, and slags, to be able to draw correct conclusions on this subject, especially as pig-irons Nos. 113 and 114, cast at the New Hampshire furnace, do not contain more than an average amount of manganese.

A few general remarks on the chemical composition of the various specimens of pig-iron analyzed, may be useful: No. 89 contains the largest quantity of silica, 6.88, which has evidently an injurious effect on the quality of the iron, as it is particularly noted that when such iron is produced the furnace is working stiff, the iron is "*high*," and no doubt has *cold-short* properties. This could easily be corrected by *increasing the quantity of limestone flux*, until the cinder flows free, and assumes

the appearance and composition of the *true bi-silicate*. This iron also contains the largest amount of manganese, 0.63. No. 114 contains the largest amount of phosphorus, 1.4, and the largest but one of aluminium, 0.44, and the largest amount of graphite, 3.13, per cent. It is singular that though this pig-iron is light-colored, and fine-grained, it is yet comparatively soft.[2] The same remarks will apply, in a great measure, to No. 113, which contains only 0.08 more aluminium, and 0.1 less phosphorus, 0.3 less graphite than the preceding. The largest amount of free carbon was found in No. 48, a soft grey pig-iron of a fine grain. The largest quantity of slag, 0.93 per cent, was obtained from No. 87, a soft but rather brittle iron. This iron also contains a large proportion of silica, 5.13, being only 1.75 less than No. 89, as well as a large amount of manganese, 0.59, which is only 0.04 less than No. 89. No. 42 contains the largest quantity of magnesium, and is a moderately fine-grained soft grey cast iron. No. 113 contains the largest amount of alkaline bases, viz.: 0.33 potassium, and 0.21 of sodium.

Since the Greenup county *impracticable ores* are so rich in iron, and *four feet in thickness*, their successful reduction in the furnace becomes a matter of great practical importance, not only to the owners of ore banks but to the State of Kentucky.

I would here also call the attention of iron-masters to the variable composition of the limestones used as fluxes at the different iron establishments in Greenup county—see Nos. 39, 51, 62, 63, 77, 84, 108 and 109 of Dr. Peter's Report. The amount of insoluble silicates, ranging from a half to thirty per cent, showing the importance of a knowledge of the chemical composition of the limestones, as well as the ores, in adjusting the proportions of each. The composition of the limestone selected should always have relation to the composition of the ore to be fluxed; for example, though a limestone like No. 84, containing thirty per cent of insoluble silicates, might be appropriated for ores deficient in silicious earths, like Nos. 36 and 38, it would be altogether inappropriate for ores similar to specimens Nos. 31, 32, 50, 54, 57, 69, 72, 80, 84, 94, 103 and 105, with which it would undoubtedly produce an iron having decidedly cold-short properties. When a limestone is used for flux containing large quantities of iron, as for instance, No. 76, which yields 13.19 per cent of carbonate of iron, and 1.56 per cent of oxide of iron, it is necessary to use it in larger quantities than if it were a purer limestone, with merely a fraction of a per cent of iron, otherwise it will not afford the necessary quantity of lime to form the model cinder. Such a limestone should add six to seven per cent of iron to the furnace runs.

When it is desired to avoid making a white and brittle iron, limestone, as well as ores containing more than one or two-tenths of a per cent of phosphorus, should be avoided, since experience seems to prove that the presence of even half a per cent of phosphorus in iron is sufficient to diminish its tenacity; though pig-iron produced from certain bog ores has been found to contain five and a half per cent of phosphorus. Such iron is generally white and brittle. It is to be remarked, however, that some pig-iron which contains from four to six per cent of graphite and chemically combined carbon, may contain one to one and a half per cent of phosphorus, and yet be grey iron.

Half a per cent of sulphur in pig-iron does not appear materially to diminish the tenacity of the iron; it is even contended by some chemists that quantities of that element, under four-tenths of a per cent, rather increase its firmness. It is a

[2] See Dr. Peter's Report for further remarks on this subject.

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well established fact, however, that two to three per cent of sulphur is very destructive to the qualities of pig-iron, rendering it white, brittle and porous, expelling, at the same time, the chemically combined carbon, required to be present in the composition of good grey iron. It is true, also, that sulphur, to a certain extent, may render iron more fusible, and therefore might even be desirable to the amount, say of one or two per cent, in making fine castings, if it had not, at the same time, a tendency to cause the fluid iron to chill suddenly on the surface, before the gases and vapors have escaped from the interior and thus render the castings porous and imperfect. (Lyon in Owen.)

Owen's Diagram No. 3 of the East Kentucky Coal Field, in Greenup and Carter counties south of the Ohio river, shows in a height of 740 feet from the Tygart creek sub-carboniferous limestone, up to the Rough and Ready ore bank which supplies Sandy furnace, no less than **fourteen distinct beds of ore,** from 3 inches to 4 feet each, and yielding from 25 per cent to 60 per cent of iron from the raw ore. One of these beds from the east fork of Little Sandy near the Lexington and Big Sandy railroad location line contains 11 per cent bitumen as well as 32 per cent iron and may therefore be called a "black band" ore, averaging 12 inches thick. Another of these beds, used at Sandy furnace, contains 21 per cent lime, and is therefore as much of a flux as an ore.[3]

Sandy furnace makes from these ores a very liquid iron. The Rough and Ready ore bed lies 5 feet under a sandstone high in the hills, varies from 8 to 13, and runs up to 24 inches wherever it is mixed with a green calc rock and the ore is then poorer. It is regarded as the highest workable bed in Carter and Lawrence. It is sometimes underlaid by 2 or 3 feet of limestone. A few *producta* and *spirifera* occur in the green rock.

Mount Savage furnace uses the Stinson bank ore, high in the hill to the northeast Section :—Massive sandstone 30 feet; interval (of shale etc. ?) 30 feet; **Limestone ore** *replaced sometimes by limestone,* 1 to 3 feet; green shale 1 foot; cannel coal 3 (sometimes 5 ?) feet; sandstone 30 feet; ash shales 10 feet; **Kidney ore** 4 to 12 inches; **block ore** rough 3 to 8 inches; interval, sandstone above shale below, 25 to 40 feet; coal.[4]—Other beds of ore are spoken of near the furnace.—Mr. Lyon obtains in Carter county, one and a half miles from this furnace, the following section showing the position of the ore beds and also the contrast with the section at Clinton furnace given below:

[3] Analysis :—Specific gravity 2.8121 ;—Lime 21.8, silica 21.1, alumina 11.5, (silicate of alumina 25.6, free alumina 6.5, free silica 0.5), soda 2.5, potash 0.6, magnesia 0.4, phosphoric acid 0.8, sulphur 0.01, water 2.7, carbonic acid 18.8, protoxide iron 2.5, peroxide iron 16.7=13.65 iron.—The Top hill ore which is mixed with this calc ore yielded peroxide iron 61.0, silicates 17.0, alumina 14.0, water 7.3=42.7 iron. Mixed half and half these ores yield 28.17 iron and 10.4 lime. See Dr. Peter's Report Nos. 13, 14. Owen's vol. i. p. 183.

[4] Analysis—see Dr. Peter's Report, Nos. 116, 117, vol. i., p. 328.

378.0 top of hill near Iron-road.
372.0 top of heavy Sandstone; 351 foot of exposure.
340.8. Heavy Sandstone, top of steep slope.
292.9. Shales, clayey, at highest point of road.
275.8. Red Streak, small amount of surface **Ore.**
260 8 top of Sandy Shales; 250 soft sandy shale
244.8. top of Red Streak and foot of sandy shales.
228.8. top of yellow streak and bottom of red shales.
223.4. **Rough Block Ore,** (bottom) 3 feet thick here.
218.0. foot of Sandstone.
212.8. **Kidney Ore,** (place of the diggings, referred to the road.)
196.8. **Limestone Ore,**[5] (seen on opposite hill, referred to the road.)
191.4. top of sandy shales.
175.4 Black Streak, in shales; coal? 170.0 white clay.
138.0 Shales sandy; 135.0. Sandstone 20 inches thick.
121.0. **Grey Kidney Ore**[6] *under a 5 foot Red Streak.*
110.4. top of a 20 inch layer of sandstone.
99.8 Three Black Streaks, whitish clay between.
94.4. top of a 14 inch layer of sandstone.
83.8. Black Streak 12 inches thick, under 4 feet shales.
62.4. **Gravel Ore** in whitish earth, making a yellow streak.
57.0. top of a double 20 inch layer of sandstone.
52.4. top of a single 15 inch layer of sandstone; 41. top of slope.
14.0 Iron road; 0.0 Bed of Branch 16 feet above Gum branch coal, which is the equivalent of the Clinton furnace coal.—Passing round the head of the branch, the above ore beds have been opened extensively, and on the north side of the hill (of the section) an excellent block ore (not in the section) 75 feet below the base of the massive sandstone capping the hill, has been wrought.[7]

Star furnace has one bed of yellow kidney ore 20 feet below, and another 30 feet above, the main 5½ foot coal (110 feet below the top of the ridge). There must be therefore a third ore bed 50 feet above the coal, and a fourth skimming the tops of the ridge.[8] Mr. Lyon in speaking of the Star furnace branch of William's creek gives the following section, in which the so called "twin coal" is remarkable as a fixed horizon in all this Greenup county geology:—

Interval concealed 25 feet; sandy shale 4,	29
Coal 2 (parting clay 4 inches), *coal* 2½, floor clay 1½,	6
Sandstone and shale alternately for	20
Blue Ore Bed in shale, estimated at	3
Sandstone and shale 34½ feet; *black clay* ½	35
Star furnace sandstone,	26
Sand shales, dark grey,	80

Sand- and clay- shales alternately; *Stinson creek cannel;* the Star furnace sandstone mentioned above caps the dividing ridge between Stinson and William's creek.[9]

Buena Vista furnace has a dark ore in the same position as the first mentioned

[5] On the hill to the eastward this ore is both stripped and drifted on.
[6] The diggings are in white argillaceous shale. [7] Lyon, in Owen, vol. ii. p. 363.
[8] Owen, vol. i. p. 186.
[9] In Owen's second vol. p. 353. The identifications on the following pages are certainly calculated to excite surprise, if not some doubt.

Kentucky.

at Star furnace; but its best ore is also (as at Star) 30 feet above the coal; ten feet higher is a brown grey earthy limestone ore and twenty feet higher still is the "top hill ore," within 20 feet of the summit of the ridge. Still higher summits have a "blue kidney" ore.—Locally there is also found a "blue block" ore low in the hills, lying sometimes above sometimes below a thin coal.[9]

Clinton furnace uses the top hill fossiliferous limestone ore; a dark grey granular carbonate, yellowish outside, $1\frac{1}{2}$ to 3 feet thick; a black-band layer 1 foot thick under the coal; and a green limestone ore 25 per cent.[1] There is a nodular bed 40 or 50 feet above the main coal which at Ashland is 170 above low water at Ashland on the Ohio (=650 above tide.) The Clinton furnace ores average 30 per cent raw and 40 per cent roasted. In the cut of the Clinton furnace road Mr. Lyon gets the following section which exhibits the *red shale bands* high in the coal measures, useful here as a geological horizon, just as the red bands of the Barren measures are in the Alleghany and Monongahela river country:

Sandstone 8; yellow shale 3; black clay 2; yellow shales 5,.........	18
Red Streak 10; sandstone 11, ...	21
Red Streak 5; sandy shales 16; sandstone 5, ...	26
Shales yellow-grey 32; interval 11, ...	43

Top of soft sandstone above Ashland or Clinton furnace coal. The ore beds do not seem to appear in the section, although their places above this soft sandstone are marked in another section near the Clinton furnace thus:

$117\frac{2}{3}$ feet....top of bench and foot of 5 foot red streak.
$79\frac{2}{3}$ " ...**Ore diggings**, kidney ore.
$37\frac{1}{3}$ " ....**Ore diggings** in sandy shale.
0 ....top of sandstone over Well and under Clinton furnace coal.

The following more elaborate section at Mr. Burwell's house near the Clinton furnace is given on page 361:[2]

216.4	top of sandstone covered with red earth.
218.4	Sandstone, two beds; *locally underlaid by* **Ore, 14 inch.**
206.4.	Shales, sandy, yellow, much slipped.
191.4.	Sandstone, top of solid ledges, 5 feet seen.
180.8.	Sandstone, fossiliferous; *locally* **"top hill bastard lime ore," 8 in.**[3]
178.8.	Shales sandy, 15 feet.
154.8.	Black streak 15 inches thick; brown-red fire clay, 6 feet.[4]
147.8.	**Red block ore beds,** 10 to 12 inches thick.
137.0	Shales, sandy and clayey alternately.
116.0	**Red streak** (top of it) 5 feet thick.
108.0	Shales whitish, clayey above, sandy below.
105.4	Sandstone (top of it) in four ledges.
101.0	Shales clayey.
85.0	Sandstone 18 inches thick in beds of shale.
69.0	Sandstone 12 inches thick in beds of sandy shale.
42.10	Sandstone 18 inches thick in beds of sandy shales.

[9] Analysis—see Dr. Peter's Report, Nos. 44, etc., p. 288.
[1] See Dr. Peter's Report, Nos. 119, 120, 121, 122. Owen, vol. i. p. 329.
[2] Lyon, in Owen, vol. ii.
[3] This fossil bed is 8 inches thick, between thin shales, fossils calcareous and perhaps cement calcareous; sandstone fine grained.
[4] From 147.8 to 156 are the beds producing the red streak across the country.

32.00 **Carbonate of iron**, sheet 2 or 3 inches thick.
20.4. Clinton furnace coal (roof) 4 feet thick.
0.0. Shales sandy and then Hard Sandstone over Well coal.

Bellefonte furnace has its main ore over a bed of limestone ranging extensively through the neighboring hills. The ore varies from 1 to 4 feet, in dark ash shale, hematized at the outcrop.—At a lower level lies a "blue limestone" ore under a sandrock.[5] These raw ores yield 31 per cent metal on the average. Mr. Lyon gives a section here, to contrast with one at Hood's creek, a mile off, to show how rapidly the measures change:—

8	feet earth above limestone.	Clay stripped, . . .	feet 15
3½	" argillaceous shales.	**Limestone ore** . . .	⅔ to 1
¼ to ¾	**limestone ore.**	Limestone	1 to 4
4	feet limestone.	Fire clay	2
1	foot shales.	Blue-grey shale 18, sand 15	23
21	feet pebbly coarse sand.	Black shales . . .	14
2½	" coal streaks in shale.	Coal 3½, under clay 2, .	5½
31	" sandstone.	Sandstone	31

Mr. Lyon gives at Bellefonte furnace four sections No. 14, 14*a*, 14*b*, 14*c*, (the first made in Lanheim hollow on the company's lands, to show the whole series of rocks for 200 feet; and the second on Wolf hill west side of Hood's creek, the third opposite the drain, and the fourth three hundred yards further south) to show the variations in the limestone ore bed.

No. 14.

Hill top	198	feet	0
Interval................	80	"	0
Clay shale.............	12	"	0
Stripping..............	2	"	9
Fire clay..............	4	"	4
Black clay.............		"	7
Sandy shale............	3	"	6
Limestone Ore........		"	8
Limestone[6]	5	"	5
Clay bed, coal[7]	5	"	0
Sand shales.......	31	"	0
Interval, coal		"	7
Hearth rock	7	"	0
Sand shales............	'22	"	0
Interval................	15	"	0

No. 14*b*.

White clay shale	13	feet	0
Black clay shale........		"	10
Ash clay shale	4	"	0
Black clay shale........	1	"	0
White clay shale.......	4	"	0
Limestone ore........	1	"	0
Limestone.............	4	"	6

No. 14*a*.

Hard sandstone.........	10	feet	0
Clay shale.............	7	"	0
Black clay shale		"	10
White clay shale.......	7	"	0
Limestone ore........	1	"	2
Sandstone.............	10	"	0

No. 14*c*.

Alternate beds white and black clay four black in one foot thick each.	27	feet	0
Limestone ore........	1	"	6
Limestone	4	"	6

[5] Dr. Peter's No. 49 to 53.

[6] Limestone, upper surface water worn and uneven; beds lumpy; lower beds in ledges of even thickness.

[7] Locally a thin coal.

Amanda furnace is the only one of all the furnaces in the Ohio and Kentucky Hanging Rock region which stands upon the Ohio river; a mile above Ironton on the Kentucky side. Its principal ore beds lie 290 and 310 feet above low water, in nests, through ferruginous shale. Its "blue block" ore with shales lies 95 feet above low water, but is accounted silicious and impracticable, although Dr. Peter found in it but 9.6 per cent insoluble silicates. He suggests that it contains too little and not too much; melts too quickly and cannot form a slag to protect the iron from the blast; it should be worked with earth or earthy ores. The tough iron ores of Amanda furnace were found to contain 20 per cent silicates, and the red and blue mixed black ore 25 per cent. Here were obtained the slags of various colors experimented on as said above.[8]

Kentucky.

Carolina furnace uses ore on limestone 150 feet above the main coal (3 feet thick), and also a top-hill yellow kidney ore. A section here is as follows:[9]

250 top of dividing ridge between Indian creek and Ohio waters;
240 **Rough top-hill ore** 8 to 15 inches, under balls.
Shales and sandstones 40; interval 10; shale 5; soft sand 21;
168 interval place for **Limestone ore and Limestone** 10;
Sandstone (slipped down?) 10; shale 10; fire-clay? 5;
125 place of **ore bed** of steam furnace at 152, but nothing but some loose ore found which had come down from the limestone ore place at 168; interval 10; soft sand shales 15; clay etc. 16; black clay 3;
80 place of Clinton furnace coal? interval 36;
sandstone 37; black shales and then
7 coal; equlvalent of Star, Steam, Clinton, Indian creek coal;
0 underclay; sandy shales; branch bed at stack.

Steam furnace uses the same and mixes also one-sixth of a "block ore." In the hills between these two furnaces are heavy beds of limestone overlaid by 3 to 4 feet of ore. Going up to Carrington Bank is the following section:[1]

241 clay and shales 16 feet;
225 **Little block ore** and under it **balls** in clay, 5 feet;
Conglomerate and coarse sandstone 26 feet;
clay varying *from nothing to* 30 *feet;*
191 **Limestone ore Carrington Bank,** 0 to 4 feet thick;
Limestone (flux), 5 feet (at Steam furnace 8 feet);
clay beds 10; interval 16; clay 16;
152 **Block and kidney ore**[2] "6 to "15 on coal-streaked clay;
Sandstone 5; clay shales 5; shales and sands 38; *sandstone;*
93 **Little block ore;**
clay and mica sand-shale. 32 feet; **coal?**[3] and underclay 5;
clay and mud sand-shales 21; sandstone 35;
0 Datum at Clerk's house, 6 feet above bed of branch.

[8] Owen, vol. i. p. 191.
[9] Lyon in Owen, vol iii. p. 435.
[1] Lyon in Owen, vol. iii. p. 432.
[2] Equivalent of main Raccoon and Buffalo beds, and the Buck Smith and Red Bank Laurel beds.
[3] Equivalent to the Indian run coal, Caroline furnace coal and Clinton furnace upper coal.

Pennsylvania furnace smelts eight varieties of ore, six of them hydrous-peroxides (limonite outcrops of carbonate beds), and two of them carbonates. There are four principal beds above the Four fort main coal, besides minor local beds; a little block ore 4 inches thick 30 feet below the coal, and 10 to 15 feet under a sandstone quarried for hearth-stones which itself contains from 25 to 35 per cent iron; a rough inferior block ore 110 feet above the coal; a limestone ore, average 18 inches thick, 130? feet above the coal, 42 per cent iron, 21 per cent carbonate lime; a rich limonite over limestone 51 per cent iron *and no carbonate of lime*, place unknown to Dr. Owen; a top-hill ore, 8 inches average, 38 per cent iron, 14 per cent carb. lime; a limonite (very pure 61 per cent iron!) 3.5 silicates and no carb. lime, accounted impracticable at the works, but only needing mixture; a four-foot carbonate bed (over limestone) 39 per cent iron, 9.5 per cent silicates, 3 per cent carb. lime, also considered impracticable at the works. but easily made valuable by mixing with lean ore, black slate, and an extra dose of limestone.—In the hills between Pennsylvania and Greenup furnaces, a cannal coal underlies the top-hill ores.[4] Lyon gives the following section ascending Cane creek, by the road to the latter:

244.8	top of hill, loose Rough Sandstone
228.8	**Rough block ore** bed; 217.0 top of covered slope.
162.8	Soft sandstones on an interval of sandy shales, etc.
69.0	**Small ore** bed in road at foot of steep slope.
37.8	bottom of clay shales; 27.0 sandy shales in place.
20.0	top of steep slope; after which comes at water level
0.0	Sandstone (top), thick bedded, thin bedded, ledges 7 feet thick as seen between 39. and 21. of another section (at Greenup furnace) and containing fossil shells (mostly *spirifera*). Beginning with 0.0 above=39.0 we have again
0.0	top of shales, 16½ feet thick, overlying coal bed 16½ feet beneath water.[5]

Greenup furnace has seven varieties of ore, five unmixed limonites; the big block yields 47.7 per cent iron, the red ochre 18.6 per cent; the average of the seven is 37 per cent and of the six best 40.5 per cent; proportion of flux one-tenth. There is a yellow limestone which contains iron enough to work out without flux.

Buffalo furnace has its ore high in the hills, the main block being 75 feet above a six-inch coal which is 125 feet above water level; the banks are two miles off, and yield eight varieties, the eighth being a limestone 67 per cent with 11 per cent iron and only valuable as a flux. The main block 10 to 12 inches thick resting on bastard limestone with 6 inches of shale between yields 49 per cent down to 34 per cent iron The whole will average 41 per cent. The grey block carbonate 28 per cent iron containing 46 per cent carb. lime. Over the main block 1 to 3 feet (shale) lies the little block and over this kidney ore in grey, yellow and black shales; stripping 6 to 12 feet.

Raccoon furnace uses only limonite ore averaging together 52 per cent metal; the richest is the main upper kidney high in the hills, 56 per cent; the "limestone ore" *containing no limestone* (only 0.5 per cent) lies two-thirds up the hill; the red block, 11 inches thick, 53 per cent; the lower block ore, 6 inches, 80 feet up the

[4] Owen, vol. i. p. 193

[5] Lyon, in Owen, vol. ii. p. 372. The section on page 373 is interesting, but not yet identified.

hills. Charge of flux, one-tenth, cost of ore $2 50 to $3 00, charcoal to the ton of iron 200 bushels. **Kentucky.**

In Owen's 3d vol. (pp. 428 to 449) Mr. Lyon gives sixteen sections of the sub-carboniferous and carboniferous measures containing the ore beds wrought at the furnaces of Greenup and Carter counties and concludes with remarks the substance of which is here added. Most of the sections (No. 9 excepted) begin at or near the top of the Devonian knob sandstone and measure upwards into the coal. No. 1 at **Kenton furnace** shows three workable ore beds in a space of 45 feet. No 3 at **Raccoon furnace** has six ore horizons in 315 feet; those at 15 and 120-8 feet are not known as workable beds anywhere; that at 60 feet elevation is locally a valuable ore, even 18 inches thick; that at 311 has not been wrought unless the under-clay ore a mile distant be the same; the chief ores are obtained from on top of a 60 foot sand-rock (over a small worthless coal over the poor ore at 120) near the hill-tops, and reached most of it by stripping; it is known by a great number of owners' names, and supplies **Buffalo furnace** from the hill-tops between Clay lick and Old town.[6] "All the ore beds west of Little Sandy river from **Laurel furnace** to the Ohio river, except the *Baker bank* are found in this section No 3 notwithstanding the multitude of names by which they may be distinguished and the infinite variety they present at the various points at which they have been opened in this large scope of country." The following is Lyon's section No. 3, made from Raccoon furnace towards the northeast:

341	**Poor ore**; ferruginous conglomerate, top of dividing ridge;
336	**Limestone ore** beds of Laurel. Steam, Caroline furnaces;
	interval, mostly argillaceous shales, 45 feet;
	shale sandstone and clay Triplett bank beds, 20 feet;
271	**Company's ore bank**, 10 to 12 inches;
	interval. 16 feet, place of Raccoon and Buffalo ore banks;[7]
	Bluff of massive sandstone, top and bottom thin bedded,[8] 41 feet;
214	local thin **coal.**
	interval, mostly of soft shales 16; sandy mica, shales 10;
	thick *very* soft sandstone 18; soft bedded sandstone 9; sand shales 5;
155	**ore** sandy. poor, not worked, 6 inches;
	interval of thin sands, mud shales, etc 16 feet;
	coarse sandstone, even bedded 15; **hearth rock** 18 inches;
133	Shale 5, rock 1½ (used for furnace stack)
	sandy shales, etc. 35 feet;
93	local clay and thin **coal** 4 feet;
	thin soft sandstones and shale 10; interval, shales 21;
65	**Sandy ore** here 4 (¼ mile east 18) inches thick;
	sandstone soft 7; ash and grey shale 38;
15	**Carbonate ore** of XI (see sections No. 15, 16).
	dark-grey shales of Raccoon creek 7;
0	**Sub-carboniferous Limestone**? at bottom of pit 8 feet deep.

[6] The two horizons, says Lyon, are certainly the same notwithstanding the remarkable difference in the ores.

[7] The horizontal position occupied by equivalent ore beds are severally thus: Brown bank 295 feet; Company's bank 340; Tipton bank 350; all in one hill.

[8] The middle of this mass is very thick bedded, composed of thick angular sand and quartz pebbles, marked by ferruginous belts and patches.

These beds at Laurel furnace in the following section contain the **Baker Bank** ore stratum excepted by Lyon from the section just given. The upper 89 feet of this section is quite local, capping only a few of the hills:

465 interval, clays, etc. 89 feet.
376 interval shales, 4 to 30 feet; sandstone 30 to 4 feet, the sandstone being local and often *pebbly;* dark clay 1 to 30 feet.
367 **Baker Bank Limestone Ore.**
Coal from 0 to 4 feet thick; fire-clay 1 to 4; shale 1 to 10 feet; interval in all 38 feet containing
Place for Red and Buck Smith Banks.
229 top of bench (sand?) 10; clay; shales 5; sand 1; shales 15; **clay 4;** sandy shales 30; flag stone 5; *black clay shale* 4 to 5; shaly sandstones 16; soft coarse (Raccoon bosh) stone lower part false bedded 15; drab micaceous sandy shales 27;
187 **Sandy, kidney, block Ore,** 3 to 5 inches; shales 10; interval 10; shales 30; **Raccoon hearth rock** 43;
93 **Lowest Ore bed** at Laurel; rough, block, sandy, shales, etc. 17; sandstone, flagstone, etc. 55 feet;
0 top of Laurel furnace stack; thin bedded hard sandstone 10; sandstone ledges solid, 6, 7, 8, 9 and 10 feet thick each; XII;
50 under which come shales and a small coal and then the **sub-carboniferous limestone** XI.

The character of these ore beds may be studied in the following sections 12 (a), 12 (1a), 12 (2a), 12 (b), 12 (1b), 12 (2b), 12 (3b), at the different banks:

12 Island Bank.[9]

Thin flag-stone	1"2
Clay irony shale	4"0
Mud sandstone	1"0
Calcareous ore[2]	"2
Sandy mudstone	"3
Block ore	4"0
Sandstone	"3
Rough blue block ore	"9
Soft sandstone	38"0

12 (a) Dennis Sheridan Bank.[1]

Argillaceous shale	3"0
Kidney ore 3 to	"6
Sandy shale	2"9
Little block ore "3 to	"5
Blue block, not used	"9
Sandstone, top soft	38"0

12 (1a) Moran and Cramp Bank.

Stripping earth	4"0
Kidney ore decomposed	"6
Fire-clay, good	3"0
Reddish clay shale	1"0
Muddy sandstone	"10
Solid block ore[3]	2"2
Sandstone	38"0

12 (2a) Buck Smith Bank, Laurel Furnace.

Stripping earth	5"0
Fine hard sandstone	1"8
Fire-clay, coal streaks	7"0
Kidney ore "8 to	"12
Square kidney ore	"4
Limestone ore double[4]	1"8
Sandstone, top thick	40"0

[9] On Island Bank Buffalo furnace chiefly depends.

[1] Formerly Bailey Bank, Buffalo furnace.

[2] Contains entrochites.

[3] Of Uniform texture throughout, separating into two unequal parts by a line parallel to neither face of the bed.

[4] Contains entrochites.

12 (t) Tipton far Bank, Raccoon Furnace.

Stripping earth	4"0
Lumpy sandstone	1"0
Fine sand shale	4"3
Coal streak	"1
Fire-clay dark grey	2"0
Black clay shale	2"6
Variegated shales	1"6
Red ore, double	1"0

11 (1b) Blue Block Bank Raccoon Furnace.

Stripping earth	4"0
Clay shale, coal streaks	7"0
Kidney ore	"5
Clay shale, black streaks	2"9
Little block ore	"3
Red ore	"6

Sandstone soft; then massive containing pebbles; in both sections ..... 50"6

12 (2b) Poynter Bank, Raccoon Furnace.

Stripping	4"0
Clay shale	2"0
Kidney balls in clay	3"9
Block Red ore 3 to	"8
Blue fine ore	"12

12 (3b) Company Bank, Raccoon Furnace.

Stripping	5"0
Sandstone with plants	2"0
Clay shale	7"0
Block ore[5] 18 to	2"0

Soft sandstone; then massive sandstone; in both sections 500

Laurel furnace has its lower bed 95 feet above the forks of Old Town creek, but its principal beds from 25 to 40 feet below the tops of its ridges, in black, yellow and grey shales. The main block is 14 inches thick and worked by drifts as well as stripped. It is mostly dark brown or red, passing downwards into a ferruginous limestone and upwards into Kidney ore. The main Baker ore bed runs from 6 to 16 inches and underlies the Kidney ore, with shale between. The Ward ore runs from 4 to 6 inches. Locally the Baker ore becomes a limerock 3 feet thick. The Birch bank Kidney ore *has sulphate of lime in its fissures.* The Conglomerate sandstone (XII) seems to face the creek banks.

Kenton furnace has banks near by and two miles off, and principally uses (two-thirds of the burden) block ore, 6 to 8 inches thick, 290 feet high in the hills; the other third is limestone ore 60 or 70 feet lower, 8 inches to 3 feet thick. A little kidney ore overlies the block and both cost $2 00, the limestone ore $2 50 at the furnace. This limestone ore must be one of the lowest in the coal measures here.[6] Flux charge, 40 lbs. to 700 lbs. roasted ore; iron tough bar, axe, car wheel.

New Hampshire furnace uses ores in the same geological position as the last described. Its "speckled ore" or ore of XI, has been already described. Its five other kinds are hydrate outcrops of the coal measure ore beds. The block ores occur near the hill tops. The limestone ore varies from to 4 feet between sandstone and limestone, the latter thinning out from the head of Buffalo to White creek.[7]

In Lawrence, Johnson, Floyd, Pike, Letcher, Perry etc., Dr. Owen describes or alludes to numerous exposures of coal measure ores few of which seem to be of prominent importance, although some are of interest. The kidney ore of the Swift mine on Yellow creek of Log mountain near the furnace line, contains some disseminated sulphuret of zinc and lead, and white powdery hydrated silicate of alumina.[8] The equally notorious "silver" iron ore in Whitby county below the falls of the Cumberland is

[5] Fifty yards from this bank this solid bed is subdivided into two by a muddy sandstone which attains the thickness of 12 inches; ores and sandstones very unevenly bedded; the ore beds averaging 8 inches each.

[6] Is in fact the ore of XI described on page above.

[7] Owen, vol. i. p. 199.

[8] Vol. i. p. 222.

the sub-carboniferous ore of XI; contains 42 per cent iron and also contains occasionally disseminated sulphuret of iron, zinc and traces of lead, antimony and arsenic, and the same white powdry *scarbroite.* In **Pulaski county** there is not only this ore bed 15 or 20 feet above the sub-carboniferous limestone, but another and probably more productive one 90 feet above it, which would put it in the neighborhood of the first bed of coal above the conglomerate.[9] In the southeast part of Pulaski the coals of the Cumberland and Rockcastle rivers can be traced along the waters of Indian creek with considerable beds of carbonate of iron occupying a geological position apparently identical with that of the Nolin beds in Edmonson.[1]

In the level country of **Laurel county,** underlaid by the conglomerate, the shales of the lower coal measures contain large quantities of ore, associated with a 3-feet bed, well worthy attention from iron manufacturers. The exact place spoken of is on the White Oak branch of Little Rockcastle river. Where the Mount Vernon road crosses the Rockcastle, the section is as follows:—Millstone grit (XII) sandstones 60 foot; shaly sandstones and ferruginous thin bedded shales, including much silicious oxide of iron, 238 feet; sub-carboniferous limestone 102 feet down to water edge and consisting of limestones and marly shales with some hydrated oxide of iron especially in the shale near the upper limit. Strange to say on the other side of the river the sub-carboniferous limestone stands but 40 feet out of water and is capped directly by a coarse conglomerate.[2]

The scheme of the West Kentucky coals given in Owens vol. i. p. 46, is as follows:—

	Anvil rock interval . . .	43 feet
1. Coal, $1\frac{1}{2}$ to 3 feet . .	interval . . .	46
2. Coal (Middle) 3 feet .	interval . . .	67
3. Coal (Main 5-foot "Pittsburg" Lesq.)	interval . . .	86[3]
4. Coal (Well) 2 to $2\frac{1}{2}$ feet	interval . . .	112[4]
5. Coal (Little vein) 3 feet	interval . . .	65[5]
6. Coal (Four-foot) 4 feet	interval . . .	95
7. Coal (Curlew) $2\frac{1}{2}$ feet .	**Iron ore** interval . . .	157
8. Coal (Icehouse) $2\frac{1}{2}$ feet	interval . . .	154
9. Coal (Bell) 4 feet . .	interval . . .	73
10. Coal (Cook) $2\frac{1}{2}$ feet . .	whole distance . .	998 feet.

[9] Vol. i. p. 237.
[1] Vol. i. p. 238.
[2] Vol. i. p. 242.
[3] On the Saline, 100.
[4] On the Saline, 95.
[5] On the Saline, 32.

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These coals are rearranged in the Third Volume and numbered not downwards from 1 to 10 but upwards from 1 to 12. The iron ores of the shales immediately overlying the Icehouse coal (Lyon's 8th and Lesquereux's 3d[6]) are described on pages 56, 57, as "important beds of calcareous iron-stones," capable if required of being mined in connection with the coal, which itself is described as the best coking or furnace coal bed in the region. It is curious that the bed in Pennsylvania with which Lesquereux is disposed to identify this bed is a particularly fine iron smelting coal, as where it appears between the Beaver and the Conneconessing rivers, *overlying* there at some distance the buhrstone iron ore. Of the ore, Dr. Owen says, that in the ten feet above the Icehouse coal there are seven or eight distinct bands, partly continuous and partly interrupted. Having opened up their outcrops fairly to measurement, he estimated the average thickness of each band at 2 inches (from 1 to 4), of the whole at 16 inches. A fine-grain specimen is thus described:—Specific gravity 3.135 to 3.591, iron 43.76, oxygen 10.84, carbonic acid 31.00, silicates 8.50, etc. A coarser specimen yielded 30.3 iron, silicates 30.0, etc.[7]—Above these shales and a sandstone on top of them are other shales containing beds of nodular ore.

Besides these deposits, Owen considers deserving of attention as containing ores the 40 or 50 feet of shales over the Main coal and the 3 or 4 feet of shales beneath its underclay; the shales over the sandstone over the Well coal; those under the Four-foot coal; and those at the base of the Finnie bluff. Under the Well coal is another sandstone in the shales under which he found in some places five regular bands of calc-ironstone, from 2 to 6 inches (specific gravity 3.6, iron 27.5), or 14 to 17 inches in 12 to 14 feet.[8] Judging by the experience of the eastern works it is not likely that any of all these named deposits will ever be used to profit.

In Muhlenberg and Hopkins counties in western Kentucky numerous beds of crop-brown-hematite and of ferruginous

[6] Perhaps; see page 534, vol. iii. Kentucky report.

[7] The 8-inch vein in the Hawesville section on the Ohio river has much clay ironstone over it and may identify itself hereafter with this Icehouse coal of Union county.—*Owen*, i. p. 180.

[8] Kentucky Report, vol. i. p. 58.

black slate (so called blackband ore) occur.[9] With regard to the latter Dr. Owen and Dr. Peter agree after numerous analyses that only such specimens as have a specific gravity of 2.9 to 3.0 and upwards, and present layers of black and brown, or reddish-grey colors, can be considered productive. Samples tried from Hopkins county weighing 2.56 to 2.71, uniformly black or grey-black, only yielded 6 to 7 per cent iron, while they contained 40 to 70 per cent carbonate of lime. As in the eastern coal fields the beds of carbonate of lime become beds of carbonate of iron, and vice versa, without betraying the change to ordinary observation, so in the western coal regions where the lime is more generally diffused, beds of black carbonaceous limestone become beds of black ferruginous limestone, or vice versa, lose their iron and take more lime, while they retain their bitumen. No specimen of iron ore of this sort can be considered worthy of attention then unless it weighs at least two-thirds ($\frac{2}{3}$) as much in water as it weighs in the air.[1]

A bed of iron 3 feet thick under limestone is *reported* as passed through in the Kurzeman shaft at Williams landing on Green river; and 3 feet shale with ore under limestone occurs at Davies's ridge in Cypress creek and Pone river forks in the northern corner of Muhlenberg county.[2] This Williams-landing-shaft section as given on page 143 reads thus: Limestone 3 feet; **iron ore** 3 feet; sandstone 15 feet; shale 15 feet; coal 8 inches, said to be 4 feet on Pond creek; hard bands of sandstone with shale bands and some iron-stone layers 58 feet; "**black-band**" 1 foot; coal 2½ feet, brash; fire-clay 4 feet; **iron ore balls** and bituminous shale 6 feet; hard calc rock containing pyrites 3½ feet; sandstone etc.

A slaty "**black-band**" ore, yielding 36.5 per cent iron, 2 feet thick, under clay slate with nodular ore, and over black shale (5 feet) over coal (2½ feet),—and a 2½-foot 43.5 per cent ore bed (Jenkins' bank 4 miles southeast of the stack) furnished the running stock of the old Buckner furnace in Muhlenberg county, west Kentucky, south of Greenville.—A fossiliferous ore several feet thick, mixed with the other two kinds, was obtained on Lick creek ridges, two miles southeast. The want of capital and bad construction of the stack caused the abandonment of the furnace; the location is a good one.—A 37 per cent "black-

[9] Page 59. [1] Owen, vol. i. p. 60. [2] Idem.

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band" ore "19 inches" thick was struck 25 feet down Ford's well, Pond creek, resting on black shale, and is the same bed no doubt as that above, and as a 31 per cent ore found between old Bucker iron works and Turner's. It is possible therefore that a bed which seems to be persistent over a considerable area may be found workable at more than one point of its outcrop.[3]

Near the northern limits of Edmonson county, the shales of Nolin creek show several valuable beds of ore, distributed in the 60 or 80 feet of the upper part of the following section:[4] **Ore at the top of the hills** 6 inches; shale 8 feet; **middle bed of ore** in 2 feet of ferruginous shales; shale 10 feet; sandstone 20 feet; coal, locally; place of the **fossiliferous ore** seen further north, but represented here by nodules in dark shale 10 feet; sandstone 18 feet; grey slate 1 foot; coal (main Nolin bed) 4 to 6 feet; **nodular ore** in sandy shales 20 feet the equivalent of the Conglomerate No. XII; coal 4 inches under which come the marly shales and limestones of the sub-carboniferous.—The lowest of the three deposits (neglecting the nodular ore under the Nolin coal) is more earthy than the middle ore 20 or 30 feet above it. There appears very little hope of these beds being profitably wrought.

Into Indiana and Illinois extend the coal measures of western Kentucky. Two furnaces run in southern Indiana; the Richland (K 615) "uses bog, block and limestone ores, chiefly the latter, costing $1 25 per ton at the tunnel head." Indiana furnace (K 616) runs on what is called "brown hematite," which however must be the outcrop of a calcareous protocarbonate ore, for it contains enough lime to flux itself and yields but 33 per cent of metal. A four-foot vein of coal underlies the premises.

In **Illinois,** the Martha and Illinois furnaces (K 613, 614) between the Ohio and Saline rivers, run upon the ores of the lower coal measures, honeycomb, pot and pipe. The ore banks of this and of the Illinois furnace were worked until they headed up between well defined walls of limestone, the ore fill-

[3] Owen, vol. i. p. 140. [4] Vol. i. p. 164.

ing two distinct fissures running parallel to each other, with a uniform bearing north 15° east, one of which was 24 feet wide and worked to a depth of 60 or 70 feet, and the other $27\frac{1}{2}$ feet wide and worked down 90 feet. This last supplies Illinois furnace. An analysis from an average specimen of the Martha furnace ore banks, yielded 80.00 per cent peroxide of iron =56.02 iron. (See Dr. D. D. Owen's Report to the S. C. and M. Co.) A ton of it required 200 bushels of coal (at 4 cents per bushel) with a blast from two iron O^2 cylinders 3+5 feet, and ran about 18 revolutions to the minute.[5]

In Dr. Norwood's pamphlet report published in 1858, the coal measures of Illinois do not exhibit a single workable bed of iron ore. What iron does occur presents itself as a sulphuret, interstratified with the coal shales and layers of coal, in lens-shaped masses between the layers, and in thin plates occupying vertical fissures crossing the beds.

In **Iowa**, where we see a continuation of the great western coal area, the report of Prof. Hall, just published, dispels all the hopes once entertained of finding workable beds of iron ore. In the lowest division of the coal measures spread thinly over the southwestern portion of the State no beds of carbonate of iron can be discovered.

In **Missouri** the same is true. Although Prof. Swallow estimates the thickness of the Coal Measures in this State at 1,070[6] feet, his reports of 1855 show that they contain no ores. Dr. Shumard says " We had reason to expect the existence of considerable quantities of iron in the coal measures; but it has not been observed, in workable quantities, in a single locality in these rocks.[7] It seems as though the carbo-ferruginous muds descending the rivers of the Atlantic continent were unable to reach these western portions of the Carboniferous Sea.[8]

Thus far we have been speaking chiefly of the lower coal measures. The **Upper Coal Measures** are far less rich in iron

[5] Bulletin American Iron Association, 1858. Compare the Lead ores.
[6] Proceedings Amer. Assoc. F. A. S. Baltimore, 1858 (Cambridge, 1859).
[7] Shumard, in Swallow, page 158.
[8] In Minnesota iron and coal are reported in abundance along Blue Earth river Amer. R. R. Jour., 1851, p. 805. But it is a mere report.

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than the lower. They too obey the law which seems to limit even what little of iron wealth they have to the eastern margin of the Carboniferous Sea. It is along the eastern outcrop of the **Pittsburg coal bed** that we have almost the only remarkable deposit of carbonate of iron known at present high in the formation, and almost all that we know of it comes from Dr. Jackson's report to Mr. Rogers condensed in the Third Annual Report of 1839 and embodied in the Final Report vol. ii, page 504 and from 603 onwards.[9] The expression eastern outcrop of the Pittsburg bed is here used, because the small patches of this bed in the Ligonier, Somerset and Broadtop basins towards the east are all that is left of it over that wide interval, until it dips into the Anthracite coal basins of the Schuylkill country.

The **ore of the Pittsburg bed** begins to appear as far north as Blairsville on the Conemaugh, as nodules of carbonate of iron and carbonate of lime in the shales (18 inches thick) beneath the coal. But no important quantity is seen until we pass to the south of the Loyalhanna head waters, the Sewickley and the Youghiogheny river. In the region southwestward of the Redstone creek where the great limestone deposits above the Pittsburg bed take the place of the two large coal beds elsewhere occupying the same position,—a region therefore of unusual mutation in the times which followed the formation of the Pittsburg coal,—there was a change in the condition of things of equally curious significance in the times which immediately preceded its formation. Here it is that the ore bed is developed. It is not seen along the Youghiogheny, where sections are numerous.

On **Redstone creek** the ore varies from 2 to 8 inches over blue slate and under fire-clay (18 inches) under blue slate ($4\frac{1}{2}$ feet) under Pittsburg coal (7 feet) at Wynn's bank. The ore is carried to Oliphant's furnace from this and other numerous openings between Redstone and George's creeks. It comes out in blue fine-grained compact roundish cakes, traversed by crystalline white veins. South of the furnace the Pittsburg coal recedes from Chestnut Ridge and rises in the hills along its narrow basin. South of George's creek at Davis's bank it contains

[9] It is necessary here to guard those who consult the writer's map of Pennsylvania accompanying Prof. Rogers's Final Report, against a gross geological error which was caused by its being engraved and colored in Edinburgh. The two principal limestone outcrops of the coal measures, it will be noticed, *run together* north of Blairsville, instead of running parallel in two separate blue lines along the western side of the Chestnut Ridge into Virginia.

pyrites and slate in flattened discs or plates. Across the Virginia line, half a mile, at Rubble's bank, the ore has been wrought for Duncan's furnace. Between Redstone and George's creeks, on the anticlinal axis on Cat's and York's runs the ore has been obtained at numerous banks.

On the Monongahela, two miles above Port Royal there are ten bands of ore (the lower nodular) in 20 feet of shale beneath the Pittsburg coal. At Greenfield, some layers of ore 3 inches thick are seen in the run 20 feet below the coal. East of Brownsville and three miles from the National road, one of the layers of the ten foot limestone under the coal contains nodules of ore. Three miles southwest of Carmicheltown nodules are seen under a coal which may perhaps be the next higher (Sewickley) bed. Large quantities of flattened balls are seen in the 20 foot shales under the coal upon Muddy creek.

The second bed above the coal, the Waynesburg bed, shows on Laurel run which enters Ten-mile creek two miles below the town of Waynesburg a top slate hard and ferriferous, containing beds of rounded pebbles, and flags of pyritous carbonate of iron an inch thick, of silvery lustre.[1]

The general formula given in the Third Annual Report[2] may be condensed as follows:—

Pittsburg coal.

Limestone, k, dark blue and black layers, 1–1½ feet thick, separated by shale, the main body of shale above and of limestone below; black layers ferruginous and bituminous. Shale full of iron ore along the base of Chestnut Ridge, in George and Union Townships, Fayette county.	
Ore, carbonate of iron, in 3 layers; first, 2 feet, second, 4 feet, third, 7 feet below the coal. At Brownsville and Connelsville a thin coal bed separates the two lower layers of ore, ...	25 feet.
Shale and Sand; grey slate, thin sands, soft shales; near Pittsburg a building stone; ripple marks, reeds; deposit universal, ...	30 "
Limestone, j, dark blue, weathering yellow; hard, heavy, square, oblong debris along the Monongahela and Youghiogheny, ...	4 "
Red *and Yellow Shale,*	12 "

[1] Final Report, vol. ii., page 650. [2] Page 87.

Pennsylvania.

It will be seen from the above description how very local this ore deposit really is,[3] and how little it disturbs the rule that the opening of the great coal era was almost the culmination of the exhibition of the carbonate ores.

The gap which formerly was thought to exist between the Palæozoic and Mesozoic ages,—between the Coal Measures as the close of the days of ancient fossil life and ocean deposits, and the New Red and Jura formations,—after being filled up roughly by the discovery of the missing intermediate rocks in the Uralian regions of Russia, in the ancient kingdom of Perm, has been more nicely joined by the latest discoveries in the United States. Rocks which are evidently the direct continuation of the coal measures upwards, in Illinois, and in Kansas, have furnished unmistakable Permian fossils. And other rocks upon the Atlantic seaboard, which are as evidently immediate, conformable predecessors of the Lias and Oölite, contain magnesian limestone,[4] and animal remains over which there is still indeed dispute, but which approach if they do not fully accord with a Permian type.[5] It is not certain however that the continuity is as yet obtained unbroken. The top of the eastern coal measures ends horizontally in air, one or two thousand feet above the Pittsburg coal; while the bottom of the New Red is buried in a granitoid trough at a topographical level 3000 feet lower, and in geographical distance 300 miles off. These uppermost barren coal measures of southwestern Pennsylvania and northwestern Virginia should cover the geological interval apparently occupied by the 820 feet of so-called Permian rocks

[3] Carbonate of iron occurs under the supposed representation of the Pittsburg coal in the Salisbury basin in Somerset county, but it has never been wrought and is probably of no value.

[4] See Dr. Hitchcock's book on the footprints of the Connecticut river sandstone, and Dr. Emmons's paper on the Chemical Constitution of certain Members of the Chatham series in the valley of Deep river, North Carolina, page 230, Proceedings Amer. Ass. F. A. S. 1858, Baltimore meeting. The presence of magnesia in great quantities at a fixed horizon, is as good a basis of temporal comparison, as the outspread of rolled pebbles, coal, any particular metallic precipitation, or any type of animal life, along a fixed horizon.

[5] It would be dangerous to come within the wind of the Thecodont debate. Enough to say that when Leidy shows that the Mososaur is as much an acrodont as a thecodont and that Emmons's thecodont introduces still a *fifth idea* of dentation, this debate ceases to affect very seriously the question of the existence of Permian rocks in America.

in Kansas, over which again Hawn, Swallow, Meek and Hayden measure 420 feet of Trias rocks up to the base of the Cretaceous. But Hayden's explorations of the Upper Mississippi and especially his determinations of the Judith river rocks, show how nonconterminous and intermitted, although conformable, the later strata are, and thus throw doubt upon the actual continuity of the apparently conformable older strata. In the region of the west where steep dips are local phenomena there is the widest room for a deception of this kind. It is not certain that a foot of Permian rocks intervenes between the coal measures and the Trias rocks of Kansas. Neither is the palæontological evidence indubitable. Up to the end of August 1858, the fossils found in the so-called Trias were few and imperfect and resembled both Triassic and Liassic forms; while the mass of rocks called Permian, divided as they were into a lower and an upper stage, showed unmistakable permian types, but also contained carboniferous fossils throughout. The lower stage had yielded 57 *permian* species and 15 *carboniferous* species, but the carboniferous *individuals were ten times more abundant than the permian*. The upper stage had yielded some 20 permian and but a single carboniferous species. Certainly in this phase of the discussion it is a misnomer to call the lower stage *permian*, filled as it is with *carboniferous* fossils, and only beginning, so to speak, to try its hand at many other different forms, for the benefit of the succeeding age. For the same reason we must grant the propriety of calling the upper stage *permian*, only stipulating that its absolute synchronism with the permian of Europe can never be demonstrated by mere fossils. Lithologists are too facile in yielding their subscription without caveat to the axioms of chronological geology as these have been drawn up by the palæontologists. We know too much of colonies and local life disturbances to be misled. The *probability* is that we have permian rocks even in northwestern Virginia and southwestern Pennsylvania, as well as in the west; or what will as well deserve the name through fossils. But until some horizon of discontinuity be well made out, it is wiser to carry up the coal measures as high as they will go, and call the permian fossils which they contain colonial and prophetic.

The point of practical interest here however is the fact that in the Permian, or Triassic, or Liassic or Oölitic rocks, whichever

Virginia.

they may be, of the Connecticut river valley, the Newark-Norristown valley, the Richmond, Dan river and Deep river formations, there are coal beds and iron ores. The only places where these coal beds have been found of workable size are near **Richmond,** in Virginia—at Egypt on **Deep river** in the centre—and on **Dan river** at the northern border of North Carolina. The only place where iron ore of any apparent value has been mined, or in fact discovered, is at Egypt, where a bed of so-called black-band ore lies in contact[6] with the large coal bed of that little, narrow and uptilted basin. But the ore must be practically worthless if the excessive quantity of sulphur etc, which an analysis by Genth exhibits, shall prove to characterize the whole bed. It is in this double coal and iron ore deposit that multitudes of fish-teeth are found, recalling to our remembrance those (of a very different form however) in the 9th and 11th coal beds of the Kentucky carboniferous system.

Long subsequent to these embarrassing deposits, and subsequent to the cretaceous rocks, at a time when the continent was well formed and only the Atlantic seaboard was still submerged, **during the Tertiary age,** the favorable conditions for precipitating carbonate of iron in beds recurred again.

In Hartford county Maryland, Pine Grove ridge is based on a large body of argillaceous carbonate of iron like that of the coal measures, in the form of nodules imbedded in a stiff blue clay of what Ducatel in his report of 1838 calls "an upper secondary" formation, that is of tertiary age. The nodules are sometimes long and fantastically connected like irregular potatoes, compact, concentric, sometimes nucleated, growing lighter towards the centre, and sometimes hollow and lined with minute velvet-like crystals of hydrated oxide of iron and carbonate and sulphate of lime. These latter nodules yield from 40 to 50 per cent of iron in the furnace. Large quantities of them are raised from the region on both sides of Patapsco river in Anne Arundel and Baltimore counties from its mouth at Fort McHenry to the deposit on Deep run almost contiguous to the primary rocks.[7]

[6] The ore bed separates the two benches of coal.

[7] Ducatel, 1838. p. 4, 10.

Ferruginous jasper in clay, a decomposed outcrop of hornblende rock, is cut by the Baltimore and Philadelphia railroad near Elkton at Lonergen's cut through a spur of Chestnut ridge. At Flint hill near Elkton such ore was tried which proved too flinty to use. Near Northeast village several tons of good ore was used by Principio furnace,[8] the only deposit of any consequence known in this kind of rock.[9]

[8] Ducatel's Report, 1837, p. 15.

[9] On the English North Downs are certain posteocene deposits of sand, gravel and ironstone, 20 feet thick at Vico Hill as examined by M. Prestwich. Their ironstones are dispersed about the Downs. Some of the gritty ferruginous masses are full of bivalve and univalve shells of at least thirty genera, referable to Upper Tertiary age. Similar beds between Calais and Boulogne and on top of Cassel hill near Dunkirk and in Belgium, all of the age of the Crag-beds, show the wide extent of this deposit, and may bring it into line with even the tertiary deposits of ironstone on the shores of the Chesapeake and Delaware bays, since the gulf stream may have flowed then very much as it does now.

BOG.

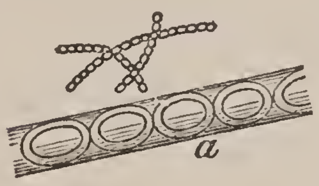
CHAPTER V.

THE BOG ORES.

Bog ore is a deposit of every age upon the actual surface at the time. In the present age the process assumes two principal forms, the dome and the layer. The former is a mechanical, the latter an organic process. The former takes place at the issues where water springs from ferriferous rocks; the latter at the bottom of peat bogs. Throughout the coal-measure areas of the west, where the rocks are outspread for thousands of square leagues in nearly horizontal strata, and their edges exposed upon the sinuous and terraced slopes of innumerable valleys, in alternate bands of slate and sandstone, coal, limestone, iron and clay, the waters, filtering out between these rocks in rows of fountains, deposit the peroxide of iron in those moist places which ferns and mosses most affect, and thus in course of time domes of wet spongy elastic bog arise, composed of an intimate admixture of three elements,—the dead and living stems and twigs of vegetation,—fine sandy clay,—and the peroxide of iron of the spring water. These domes flatten as their bases expand, and sometimes cover a quarter of an acre of the ground, where that is favorable to their reception; for this purpose is required an even, broad, and very gently sloping terrace in front of an escarpment of ferruginous sandstone based on clay or coal, or of some considerable bed of iron ore. When drained and dried these spongy masses make a favorite fluxing ore for the charcoal furnaces in their neighborhood; but owing to the sulphur they commonly contain make other neutral ores run red-short, and therefore should be mixed only with-cold short sand ores. By one of those happy adaptations which excite our pleasurable admiration for the laws which govern the material world, these bog deposits fortunately are most common in regions which exhibit heavy silicious ores of cold-short temper.

But ore of another kind is deposited upon the white clay or white sand floor of peat bogs, lakes, and swamps of every kind, in tertiary and other low and gravelly parts of the earth's sur-

face. In eastern Massachusetts the oldest furnaces were built to smelt such ores. In New Jersey and Delaware they have been wrought for many years. The southern shore of Lake Erie is lined with furnaces built on deposits of this order. In true peat bogs, a cake or pan of peroxide of iron is found at the bottom, and every tree trunk is dyed black with it. The waters which feed these bogs bring into them from the ferruginous sand hills by which they are inlocked enough of iron to supply certain microscopic animals with the material they require for their ferro-silicious shields, and these upon the death of the little creatures fall in a fine powder to the bottom of the bog or are carried into the pores of the timber it contains. Lyell figures on page 695 of his Principles (London, 1847) the thread-like *Gaillonella ferruginea* which Ehrenburg discovered in the peat bog ores of the marshes around Berlin.[1] In the United States there is comparatively little real peat; it is chiefly found on the New England seaboard; our extremes of temperature are supposed by some[2] to be unfavorable to its growth, but the lay and nature of the surface are of more importance to its formation. Our muck swamps are rather a wash of dead, than a growth of living vegetation, which, when exposed, becomes not a hard insoluble mass like peat, but a rich and crumbling mould. And the deposit of iron is essentially affected by this circumstance.



That the iron of bog ore comes in from the surrounding rocks, as does the salt of all salt lakes with their inflowing waters which can only escape by evaporation, is evident per se; but an additional proof is furnished by the fact that in some bogs *copper replaces iron.* The London Mining Journal[3] describes a copper turf, dug northwest of Dolgelly, the result of drainage from quartz cupreous rocks. The bed of dead grass and rotten oak and hazel wood, 18 to 24 inches deep charged with copper, overlay a sheet of local gravel a few inches thick, under which was another layer of peat. Some of the lower portions of the upper layer were rich in the metal, as incrustations of the green carbonate. Iron pyrites also abounded on the stones. The leaves of plants and surface of nuts were coated with a thin pellicle of bright metallic copper,[4] and the nut kernels were converted into copper. Alternate sheets of woody fibre and metallic copper were exhibited in sections of the trees. When the turf was slowly roasted and its ashes used as ore £20,000 of profits were declared in a single year.

In Chapter I. I have suggested the possible origin of some of the great primary

[1] See also Taylor's Scientific Memoirs, vol. i. part iii. p. 402.
[2] See Prof. T. P. Norton of New Haven in the Albany Cultivator.
[3] page 776. Nov. 15, 1856.
[4] Compare the fossil ore of V.

iron ore beds from beds of brown hematite, perhaps in the form of dome-shaped bog ores. It is true that we can conceive of this formation as happening on the ancient surfaces as a rare occurrence owing to the accumulations of sand rock (now granite) over such ore beds, accumulations which seem to demand submergence. But the suggestion involved brown hematite deposits of every variety of place and form, of mixture mechanical and chemical; and to say the least it is a curious coincidence, that *apatite* or phosphate of lime characterizes both the great primary ore beds of the Huronian system, and the bog ores of the present day. Forsehammer, following Ebelman in experiments to reproduce the mineral kingdom in the laboratory, with heat and such solvents as boracic acid, chloride of calcium, sodium, magnesium etc. was led to take up first the manufacture of apatite, by observing how sea water always held a small percentage of phosphate of lime and a smaller percentage of fluoride of calcium. Failing to make apatite in the wet way, and remembering that apatite occurs not only in metamorphic rocks but in lavas, he tried heat. Melting phosphate of lime with chloride of sodium, he obtained by slow cooling a cellular mass full of long crystals, which, when treated with water and then acetic acid, remained an apatite of 3.069 spec. grav scratching fluor spar. The Scandinavian magnetic ore and its bog ores contain apatite, but although Forschammer imagined it possible that the magnetic was originally bog, it is evident that much if not all of the bog is simply the drainage of the magnetic ore beds. This however offers no impediment to the conclusion that more ancient bog ores were the originals of the magnetic beds; the elements being transposed or crystallized in the first instance and transferred or deposited in the second. The present bog ore contains besides oxide of iron, phosphoric acid, lime, silica, titanic acid, and carbonaceous organic substances. The latter ingredient might correspond to the remarkable bituminous substance of the magnetite beds, and the silica, lime and manganese might be supposed to form. with oxide of iron, the numerous compounds of the amphibole series occurring in the magnetite beds, while apatite and titanium compounds might also be derived from the constituents of bog iron ore. For the purpose of ascertaining the behavior of bog iron ore when melted with chloride of sodium, a direct experiment was made. The cooled mass presented cavities which, when the chloride of sodium was dissolved out, were found to contain apatite crystals. The ore itself had become black, strongly magnetic, and had acquired such a hardness as scarcely to be scratched by steel, together with a perfectly conchoidal fracture. In the larger cavities the mass was covered with small sharply-defined crystals, which, when magnified were found to be regular octahedrons. The ore was, therefore, actually converted into magnetite, and the phosphoric acid had separated as apatite from the oxide of iron. In a comparative experiment with bog iron ore alone it did not show any sign of fusion or crystallization; the color, though darkened, was still brown.[5]

Bog ores must have been deposited in all ages, and if they could be recognized with certainty ought to be so classified, in order of their age. But as this is impossible, the only classifications at hand are one purely geographical and one geologically geographical. The latter will be here preferred, taking the regions of bog ores in the order of the age of the rocks which form the surface.

[5] Edinburgh Philos. Journal, quoted by Annual of Scientific Discovery, 1856, p. 330.

The Primary regions of the United States furnish to the surface no bog ores worth recounting because their iron ores within the surface have undergone most or all of the changes of which they are susceptible, and are neither soluble nor changeable. A peroxide under ground will not form a peroxide above ground by the ordinary processes of weathering or leaching except in peculiar circumstances. But a more stringent reason for the scarcity of surface bogs in the primary regions is, that there the rocks are usually steeply inclined and much disturbed; so that the rock waters have no chance to flow for furlongs along an iron-bearing stratum ere they issue at the spring. The bog ore therefore that exists in primary regions is of another kind, described in Chapter II; formed within fissures, or in pools, or in the veins themselves.

In the Silurian regions the same case continues; small opportunity has been afforded to form bogs. But some occur, for instance, along the outcrop of the Upper Silurian (or Lower Helderberg) limestone VI.

In the Devonian regions, where broad synclinals of Upper Helderberg limestone, cement layers, black lingula flags, etc. spread out nearly in horizontal posture, bog ores are somewhat more frequent; but are so subordinate to the brown hematite outcrops of the carbonate ore beds that they have been sufficiently alluded to in Chapter II. Where the Devonian strata reappear upon the northern and western sides of the coal areas, in New York, Ohio and central Kentucky, bog ores appear with them. In New York they have not been used; but along Lake Erie a number of old furnaces still exist and one or two continue to make iron, as may be seen by reference to the Guide, H 467 et seq. These furnaces made each 30 tons of metal a week from ore "found in the swales and swamps near and generally to the north of a ridge of land which was probably once the shore of Lake Erie, extending, with now and then an interval, along from the west boundary of the State of New York to the Huron river in Ohio.[6] The want of wood for charcoal consequent upon

[6] Of Wood county, Mr. Briggs says in his report of 1838 (Mather, p. 118), it has no bog ore; a very little was discovered one or two miles from Gilead. Large quantities occur in Lucas county four or five miles west of Maumee city.—Crawford county has a few deposits of bog ore, intermixed with sand and pebbles, near swamps. On the left bank of the Sandusky near McCutchensville masses weighing several hundred weight are found. In the southern part of the Indian Reserve a bed of a foot thick underlies a peat bog.

the clearing up of the land has occasioned the stoppage of most of these works,"[7] etc. This so called former lake shore is one of the bench-outcrops of the Devonian formation and sweeps round and flattens away in northwestern Ohio and northern Indiana.[8] In this latter State two or three furnaces, and one or two in Michigan sometimes still run upon the same bog ores.

In Southern Ohio, the Brush creek bog ores of Adams county lie in basins of limited and irregular extent, on the upper strata of the cliff limestone, and originate in the decomposition of nodules of pyrites in the rock, sulphate of lime flowing off and peroxide of iron remaining, and sometimes inclosing the sulphate of lime. Brush creek furnace on Cedar creek (south side of survey 2,615) built by Paul & McNickel of Pittsburg in 1811 exhausted the old beds and was abandoned and sold to Stewart and Company who opened new beds and blew in again in 1837. The ore is cellular brown hematite, the cells filled with fine plastic yellow ochre, outcropping along the cliffs of limestone 15 feet below the top of the cliff (150 feet above the creek), between rough and sandy layers of limestone abounding in cyathophylla and large corals. Nodular fragments of the limestone occur in the ore bed with calcareous and silicious sand. The ore banks at Steam furnace[9] are exhausted but the furnace continued to blow on ore from a distance in 1838. Marble[1] furnace was even then deserted.[2] The other two soon obeyed the same destiny, overpowered by the new Hanging Rock region manufacture.

Brush creek forge Adams county Ohio, is on the west side of the creek about 5 miles a little south of east from West Union. It was blooming up Brush creek furnace pig in 1838 when Locke reported.[3]

Approaching the Coal Measure areas and ascending the Alleghany Mountain Wall capped by Conglomerate resting on

[7] Mr. John Wilkinson of Buffalo; in Notes of Bulletin of Amer. Iron Assoc., page 166.

[8] Table K 616.4, etc. above.

[9] On a run at the head of a chasm through the cliff limestone, near Brush creek and nearly due east of Jacksonville.—(Briggs in Mather, p. 255.)

[1] Towards the Highland county line, on the road betwen West Union and Locust Grove, on Brush creek, which here flows on the flint limestone. It was owned in 1837 by Mr. Summers.—(Briggs in Mather, p. 266.)

[2] Locke in Mather, 1838, p. 252.

[3] Mather, 1838, p. 250.

sub-carboniferous red shale XI in the north and shales and lime stone XI in the south and west, with dips so gentle as scarcely to be measurable and deep ravines cutting far back between precipitous forest-clad walls sheeted with fallen blocks and local gravel drift, we see an interminable line of iron bogs separated by intervals of a few yards or of a furlong or two and stretching from the New York to the Tennessee state line. Most of them are insignificantly small and inaccessibly worthless; some few are of large size and here and there one has been excavated and smelted up with the ores below.

Back from the Alleghany mountain in the Coal Area itself, the Sub-carboniferous rises again to day in the north on the backs of five or six great anticlinals, three of which, the Negro mountain, Laurel hill and Chesnut ridge, crossing the Pennsylvania state line into Maryland and Virginia, spread out the red ore shales of XI (as has been described in Chapter IV), and furnish in great numbers the finest instances of bog ore deposits we possess. One of the most remarkable of these is to be seen on the flank of Laurel hill in Fayette county east of Ligonier, where four acres are covered to a depth of from 4 to 20 feet, the bottom layers being dark hard concreted ore and the rest a pile of alternate hard and soft sheets. Many more like it, but not all of them so extensive as this, cover the gentle slopes of this and the opposite mountain, all of them issuing from the shales of the ore of XI.[4] And in the south where fractures take the place of anticlinal waves, the repeated outcrops of XI and XII repeat the ranges of bog ores.

Along the western outcrop of the Sub-carboniferous through Ohio, Kentucky and Tennessee, sinuous, dentated, or rather pinnated like a fringe of fern leaves as it is, the exhibitions of bog ore are unlimited in number. They are however too near the outcrop of the limestone carbonates and brown hematite ores of the outcrops in the coal measures to be much regarded or often touched. In fact the precipices, at the foot of which they necessarily are formed, make of that whole belt of country an irreclaimable wilderness with a labyrinth of everlasting hunting-grounds into which no wagon can come, in which no iron-works can be sustained, except when the inter-

[4] Hodge and Lesley, Fifth Annual Report of Rogers, p. 96.

national railroads and the large rivers open it along a few narrow cross-zones of improvement and slowly growing population. In front of it stretches the narrow belt of Devonian lowland, without the Devonian ore, and back of it the forest area of the Lower Coal measures, through which the iron manufacture slowly creeps and spreads from its few centres outwards like a lichen on a rock.

On the northern outcrop alone, in northwestern Pennsylvania, have the bog ores of the Conglomerate and XI been wrought to any extent. The old furnaces on the head waters of the Alleghany river in northwestern Pennsylvania trusted for stock to the bog ores of the Lower Coal measures, which are numerous and extensive along Hemlock and French creeks and their branches. Upon Hemlock creek [5] 3 miles from its mouth one is seen covering 4 acres and 14 feet thick in the midst. Three others on Horse creek, 6 miles below, cover 3 acres each. Three miles from Horse creek furnace a bank of hard ore-nodules 6 to 10 inches thick, yellow inside and with a thin black crust, imbedded in shales, show the origin of these bogs. Small deposits occur on Sandy creek at the furnace, issuing from the ore of XI under the conglomerate. This is the fruitful source of the large and numerous bogs of the Chestnut ridge and Laurel hill slopes in southwestern Pennsylvania and western Virginia. The chief bog ores of the Clarion river also come out from under the conglomerate.

It is in the Cretaceous, Tertiary and Drift Formations of the Atlantic seaboard that the principal useful bog ores exist. The surface of New England, sculptured at a very early date (subsequent to the coal era), has been overlaid by northern drift to the depth of many yards and fathoms of sand and gravel. A new surface is the result, of a peculiar character, not channelled longitudinally in parallel lines like other parts of the land, or in all directions like still other parts, but hollowed out irregularly all over, (like the sandy bottom of a pool covered with innumerable tadpole nests touching and limiting each other,) with shallow drainage valleys irregularly connecting the whole. Hence the numberless ponds of New England, all of them surrounded by low gravel hills, up through which the original surface rocks occasionally protrude. Into these

[5] Final Report, p. 562.

ponds from the surrounding gravel hills trickle perpetual subsidies of iron to be deposited upon the bottom. The earliest furnaces of the United States, in the neighborhood of Plymouth, used these ores, dug when the ponds were dry, or around the margin when the waters fell.[6] Small furnaces and poor ore, they served their day and are forgotten; obliterated by the overrush of two commercial iron deluges, one from the English importers, and the other from the anthracite manufacturers.

In **New Jersey,** over the whole southern moiety of which the ferruginous Green-sand and overlying Tertiary formations spread, sulphatic or red-short bog ores abound in all its low grounds, along the foot of hills, in swamps, and wherever waters issue to the air and cannot flow off at once but escape only by evaporation. The Marl, containing phosphate of iron also, gives origin to bogs of phosphatic or cold-short iron ore. "Two great deposits, incomparably the largest in the State, border the principal tributaries of the Little Egg Harbor river. The most western of these is connected with the waters of Atsion river and most of its branches, extending from near the sources of these streams in a tolerably wide belt southeastward to Landing creek—about twenty miles—its average breadth three miles. The eastern tract lies along the Tulpehaukin or Wading river and its several branches, and covers an area quite as extensive as the former, but the deposit of ore is greatly inferior in abundance to that on the Atsion river particularly in the neighborhood of the Atsion iron-works." The several minor deposits are confined to the limits of the marl region; one on Talman's branch of the Rancocus; another on the south branch near its junction; another on Manasquan river near Georgia in Monmouth county; others on the Manalapan and Machaponix branches of South river.[7]

The Atsion river flowing through extensive cedar swamps from an upper country of ferruginous sands (leached and bleached white at the surface) deposits in its ponds three kinds of iron bog, "loam," "seed" and "massive" ore, which is dug chiefly from the shallow coves around the swamps, in tanks of eight or ten feet square with dykes left standing between. The

[6] See Bulletin Am. Iron Asso. notes 4 etc. on p. 78.
[7] Rogers's Report of New Jersey, 1840, p. 798.

massive ore forms the bottom layer, and the loam the top; but sometimes only one kind is met with. The loam ore is the first production, being a mixture of vegetable mould and oxide of iron, at first quite soft, but afterwards, when the iron comes to be in excess and begins to segregate and crystallize in nodules, growing harder, and finally settling to the bottom as a honeycomb mass of crystallized peroxide, its cavities filled up with yellow clay. The "young" pulverulent ore is of course most fusible. The process is so active that stumps and trunks of trees lose all their vegetable matter and are converted into solid iron ore with every line and feature perfectly preserved.

The following analyses show the presence of sand and clay brought in together with the iron:

	Perox. F.	Insoluble.	Water.	Alumina.	Organic.
Seed ore	66.10	20.53	12.54	.66	—
Fresh bog	68.90	14.00	14.03	2.37	—
Honeycomb	76.35	9.30	12.75	.23	—
Honeycomb	67.78	18.54	8.70	trace	5.00

Amount of metallic iron, 45.83, 47.71, 52.94, 47.00.

The whole Green-sand marl formation is in fact an iron ore deposit thirty feet thick composed *one-half* of silica, *one-quarter* of *prot*oxide of iron, *one-eighth* of potash, and *two-sixteenths* of alumina and of water, (48.45, 24.31, 12.01, 6.30 and 8.40,) with traces of lime and magnesia.[8] The same is true of the Green-sand of Europe except that in England magnesia replaces potash.[9] It is no wonder then that the drainage and leakage of

[8]

Three Analyses of Grains of Green Sand.	(1.)	(2.)	(3.)	*Three Analyses of Grains of Green Sand.*	(1.)	(2.)	(3.)
Soluble silica	45.510	50.010	41.729	Phosphoric acid	0.993	0.628	7.356
Protoxide of iron	21.134	21.120	16.627	Sulphuric acid	1.129	0.430?	1.005
Alumina	7.960	7.368	5.929	Carbonic acid	0.563	0.000	1.383
Magnesia	2.460	2.866	2.938	Insoluble silica (sand)	0.850	0.402	0.909
Potash	6.748	7.370	6.066	Water	9.110	9.474	7.688
Lime	3.842	0.312	8.026				

An examination of the preceding analyses will show that the soluble silica, protoxide of iron, alumina, magnesia, potash and water, are nearly the same, in quantity, in all the specimens, while the other constituents are extremely variable. It seems a legitimate conclusion that the grains of green-sand are made up of the constituents mentioned above, as being constant; and the close resemblance shown between the three specimens, when compared in this way, gives satisfactory evidence that the green-sand is a definite chemical compound.—*Cook's Report in Third Report of New Jersey*, page 66.

Composition as calculated from the Analyses.	(1.)	(2.)	(3.)	*Composition as calculated from the Analyses.*	(1.)	(2.)	(3.)
Silica	48.977	50.923	51.532	Magnesia	2.647	2.918	3·628
Protoxide of iron	22.744	21.504	20.533	Potash	7.262	7.505	7.491
Alumina	8.566	7.503	7.322	Water	9.804	9.647	9.494

[9] Rogers, New Jersey, p. 205.

many centuries should have produced immense bogs of peroxide wherever this Tertiary formation appears above the present level of the Atlantic. But the principal source of the bog deposit is the porous layer of yellow ferruginous sand lying *upon* the Green-sand marl, kept always distended with water which it dispenses to the Green-sand marl under it, dissolving out its fossil shells and replacing them with casts of peroxide of iron. But unfortunately for the iron-maker the water does not stop here, but continues down not only through Green-sand, but through or along the layers of dark-blue astringent clays which alternate with the Green-sand, and underlie it, and alternate with the Potter's clay beds underneath it. These alum beds contain sulphate of alumina and sulphate of iron, and yield them to the waters, which deposit them among the other constituents of the ore, much to its disadvantage; for its porous, powdery state prevents the usual cure for sulphur, namely, stacking in the open air, because the peroxide of iron itself would also wash away. Bog ore should not be dug long before using. Its iron therefore is necessarily hot-short and chiefly good for casting.

In the State of Delaware bog ores have been deposited in many places by chalybeate springs issuing from a sandy and clayey yellow ferruginous loam of Tertiary age forming mounds of ore through which the springs still continue to flow. These springs however actually issue in many cases from the subjacent blue clay which must therefore be fissured to allow their passage from the yellow loam above. This leaching process has been going on so long that much of the sand has been deprived of its iron.

The principal localities in Sussex county of tertiary rock ore are Collins's bank on Green meadow branch of Deep creek; a bank on Green branch, ten miles west of Millsborough, in balls and nodules, yielding ball ore; one on Burton's branch a mile west of Millsborough, yielding cold-short ore and one on Little creek near Laurel.

The Iron Hill is an outlying knob of these ferriferous sands near the head waters of White-clay creek in the northern part of the State, towering above the plain, a mass of clay, sand and gravel covered with boulders of ironstone and ferruginous quartz, spoiled by exposure. The ore mine at the top forty or fifty feet deep shows nodules of chestnut-brown, hard, tough

argillo-silicious ore, inclosed in ochre and sometimes in a coat of black oxide of manganese, scattered throughout irregular strata of white, red, yellow and deep blue plastic clay and argillaceous loam.

The most remarkable beds of sub-bog ore are situated a few miles northwest of Georgetown, near the sources of the waters flowing west, on elevated level lands, deposited in broad and shallow basins underneath a stratum of black mud mould. This kind of ore is either solid, gravelly or loamy in its structure, and these kinds are mixed in manufacturing iron. The solid ore forms the bed of the marsh, from 6 to 18 inches thick, hard, tough, brown, resinous in lustre, unevenly conchoidal in fracture, often cellular, and yielding on Analysis: Peroxide of iron 80, Water 15, Silica 5, Alumina a trace. It is therefore almost a pure hydrated peroxide, yielding when raw 55½ per cent of iron and when roasted nearly 66 per cent. The gravelly kind consists apparently of the above, broken up into nut size and disseminated through a yellow loam, but is in fact a similar sheet of ore arrested in its formation by a want of sufficient iron in the loam or a want of time to carry out the process. The loamy kind is simply a yellow ochre or ferruginous clay.[1] Since the elevation of the Tertiary Atlantic coast the drainage from the surface through these sands and clays into the lower valleys have produced chalybeate springs and the dome-shaped bog ores already described.

The raising of this ore in any quantities commenced in 1814, and up to 1841 it was estimated that 200,000 tons had been mined, of which 190,000 tons were exported from the State "introducing," as the State geologist facetiously expresses it, "not less than 600,000 dollars of capital into the State." A State that exports its raw material feeds other people's children and impoverishes its own. Had these 190,000 tons been wrought upon the spot, one-half the freight would have been saved the world, and 80,000×$25 or $1,600,000 of capital been created in the State by the first step of the process, to say nothing of the consequences.

In Maryland, in Virginia, and, in fact, the tide water country of every southern State, these ores occur and might be smelted.

Brown hematite beds, ochres etc. occur in the formation of

[1] Booth's Memoir, Dover, 1841, p. 105, 87, 43.

gravel, sand and clay, through which the waters of the primary region back of Baltimore and Havre de Grace find their way by large arms into the Chesapeake bay. The principal beds of brown hematite are contiguous to the primary limestones and probably originate from them. Ten miles west of Baltimore one such deposit supplied Hampton furnace for seventy years before it was exhausted. Others have been opened nearer to the city. Lignite exceedingly sulphurous occurs in these same sands.[2]

It was upon these contiguous deposits to the sea that the first Virginia settlers made their first essays to supply themselves with metal; essays as important then in the world's eye and to history as the grandest steps of our anthracite iron making seem to us. Thus various types of force and skill beget, succeed, and bury up each other in the many colored layers of human history, as successive types of organic life have supplanted each other in the long ages of geology.

[2] Ducatel, 1838, p. 11.

DIVISION III.

IRON AS AN AMERICAN MANUFACTURE.

CHAPTER I.

BURDEN.

THE SHAPE OF THE STACK, AND CHARACTER OF THE MACHINERY.

CHAPTER II.

FUEL.

THE USE OF THE HOT BLAST, AND ANTHRACITE COAL.

CHAPTER III.

FLUX.

THE VARIOUS METHODS OF MIXING AND THE EFFORTS TO OBTAIN MALLEABLE IRON DIRECTLY FROM THE ORE.

THE unexpected extent to which the discussion of the Ores has gone, far beyond the prescribed limits for the whole book, and the imperative necessity for publishing as early in the present season as possible to enable the Association to resume its statistical labors and bring up arrears, are circumstances which compel the author to defer this and the following Division IV for publication at some future time.

DIVISION IV.

IRON IN AMERICAN HISTORY

INTRODUCTION.

SKETCH OF THE ANCIENT HISTORY OF IRON CONTINUED DOWN TO THE SETTLEMENT OF AMERICA.

CHAPTER I.

THE HISTORY OF CHARCOAL IRON IN AMERICA.

CHAPTER II.

HE HISTORY OF COKE AND RAW COAL IRON IN AMERICA.

CHAPTER III.

THE HISTORY OF ANTHRACITE IRON IN AMERICA.

CHAPTER IV.

PRESENT STATISTICAL CONDITION OF THE MANUFACTURE.

The following summary of facts will show the objects, and thus far the success of the American Iron Association.

Summary of facts contained in the tables and notes of the Bulletin of the American Iron Association. From the Annual Report of the Secretary, March 10, 1858.[1]

During the last year the Association has accomplished the first object it had in view and obtained for the most part authentic statistics of the manufacture of iron in the United States and Canada, of 832 blast furnaces, 488 forges and 225 rolling mills. What could not be obtained by repeated correspondence was gone after, and personal search made over large areas of unknown ground; obscure and unimportant information was followed into the least accessible places, especially in the south, at great expense of time and money; so that since Jan'y 1 1857, 443 days have been spent in travelling, while at the same time a constant correspondence, arrangement and proof reading has been kept up at the office in Philadelphia. The organization of the work is now complete and efficient. The principal expense has fallen of course upon the first year of active work. One-fourth of the whole number of iron-works collected in the tables were found to be abandoned and subjects therefore of no future research, but only of history. One-third of the whole number were found to be forges, the greater part of which were occupied in making so small a quantity of malleable iron (about 7,000 tons) that they are scarcely worthy to take a place in the tables for comparison oftener than once in ten years. The future statistical correspondence and travelling will limit itself to about 900 works. Correspondence has been established between the office and influential, courteous and interested iron-masters in every part of the Union on a pleasant and permanent footing which must make the yearly collection of facts comparatively easy and cheap and reduce the expenses of the Association nearly within its income.

Accompanying each iron works in the tables is a note, more or less extended, detailing more precisely its situation and past history, any peculiarities or alterations in its shape, arrangement or working, the success or failure of experiments, the situation of mines and markets, the cost of materials in all cases where this has been volunteered by the owners, and the advertisement of any intention or wish of the owners to sell. In no other

[1] Copied from pp. 167–174 of the Bulletin.

cases has private information been sought or used; nor has any attempt been made to take account or make an estimate of the amount of stock on hand in the different iron regions, or transcend in any way the just limits of a strictly general interest, or of an impartial scientific record of facts for the use and benefit of all. It is believed that in this respect these tables and notes are unexceptionable, as they are certainly unparalleled for accuracy and extent. The Association may well claim the sympathy and support of the great body of American iron men on the strength of this first full practical representation of their interests even to their own eyes ever made. And it is evident that one of its chief values will be lost if it be not followed up from year to year with steadiness and energy.

At the close of last year there should have been a fresh correspondence opened for the purpose of perfecting the column devoted to last year's production. But the embarrassments of the business community cut off from the Association its resources at the moment when it needed them most, and it is therefore proposed to delay sending out the next circular until next December, when both 1857 and 1858 can be obtained together.[2]

The American Iron Association has exerted itself to effect an exhaustive survey and analysis of the iron production of the United States.

Wherever there has been doubt about the correctness of the information furnished us by the owners or managers of iron works, it has been checked by side inquiry, or by an inspection of the books on the spot; and all works from which no information could be obtained in any other way have been visited and examined personally. The data thus collected are therefore more than usually reliable; and where the truth could not by any means be arrived at, the fact is so stated on the face of the tables and explanations offered in the subsequent notes.* The consequence has been, on the one hand a large addition to the list of iron-works previously known and of persons interested in the manufacture, and on the other hand a material correction of the exaggerated local reports of the manufacture which have gone before for true. It is the intention of the Association to prosecute these researches periodically with the same expense

[2] A circular has however been lately issued and the results up to date of printing are embodied in this Summary.

* Viz. of the Bulletin.

of care, omitting nothing which can insure correctness in detail and furnish an unbroken history of the manufacture of iron in every one of its regions and departments.

There are three principal departments of the iron manufacture; the first represented by the Blast Furnaces and Bloomary Forges, producing crude iron from the ore; the second represented by the Forges properly so called, turning cast iron into malleable blooms and slabs; and the third represented by the Rolling Mills converting pig and malleable iron into manufactured shapes ready for the mechanic, or the civil engineer. Beyond this point the manufacture of iron cannot be followed with any present organization of inquiry, or without great expense.

The following table will show the present extent and distribution of the works in these departments and in the different States of the Union.

STATES.	Anthracite furnaces.	Charcoal and Coke.	Abandoned furnaces.	Bloomary forges.	Abandoned bloomaries.	Refinery forges.	Abandoned refineries.	Rolling Mills.	Abandoned
Maine	..	1	..	..	..	..	..	1	..
New Hampshire	..	1	..	..	..	1	..	..	..
Vermont	..	5	..	5	..	..	..	1	..
Massachusetts	3	7	..	..	..	5	1	19	..
Rhode Island,	..	..	..	..	..	..	..	2	..
Connecticut	1	14	..	..	..	6	..	5	..
New York	14	29	6	42	1	3	2	11	5
New Jersey	4	6	12	48	29	2	..	10	1
Pennsylvania	93	150	102	1	3	110	44	91	5
Delaware	..	..	1	..	..	..	..	4	..
Maryland	6	24	7	..	..	..	..	13	..
Virginia	..	39	56	..	..	43	..	12	..
North Carolina	..	3	3	36	..	..	..	1	1
South Carolina	..	4	4	2	..	..	..	3	..
Georgia	..	7	1	4	..	..	..	2	..
Alabama	..	3	1	14	..	..	..	..	..
Tennessee	..	41	33	50	2	9	3	3	2
Kentucky	..	30	17	..	..	4	9	8	..
Arkansas	..	..	..	1	..	..	..	..	..
Missouri	..	7	..	..	..	3	..	5	1
Illinois	..	2	..	..	..	..	..	1	..
Indiana	..	2	3	..	..	..	..	1	..
Ohio	..	54	26	..	..	..	5	15	..
Michigan	..	7	..	3	..	..	..	2	..
Wisconsin	..	3	..	..	..	..	..	..	..
Total	121	439	272	203	35	186	64	210	15

In working order	1159 =	Furnaces 560	Forges 389	R. M. 210
Abandoned	386 =	Furnaces 272	Forges 99	R. M. 15
In all	1545 =	Furnaces 832	Forges 488	R. M. 225

In this synopsis attention is to a certain extent distracted from the regions into which the field of the iron manufacture distributes itself by the desirableness of showing the production of individual States. There are however in fact certain geographical iron centres which are wholly irrespective of international boundary lines.

1. There is the iron region of northern New York, which formerly included Vermont and makes its iron from primitive ores by means of 40 bloomaries and a few blast furnaces, three of which are now anthracite.

2. There is the hematite and primary ore belt of the Highlands, beginning in western Massachusetts and running through northern New Jersey into Pennsylvania, containing 44 charcoal and 22 anthracite furnaces and 60 forges most of them making iron from the ore. Some of these works are of the oldest in the United States and of revolutionary celebrity. Yet the region itself hardly holds its own, in spite of its admirable location, in the present condition of the manufacture, owing to its ruinous proximity to the seaboard ports glutted as they are with foreign iron.

3. Eastern Pennsylvania and northeastern Maryland is the greatest iron region in the Union, containing as it does 98 anthracite and 103 charcoal furnaces, and 117 forges, none of which last produce iron from the ore. It is itself divisible into smaller areas, with distinct geographical and geological limits, affording primitive and brown hematite ores, and in the centre lies its anthracite region of principal productiveness.

4. Northwestern Virginia and southwestern Pennsylvania constitute together a fourth much smaller iron region, with its coal-measure carbonate ores, and its 42 furnaces, and two or three forges. Its production in the tables is accidentally increased by the circumstance that the great Cambria works of Johnstown have been built within its northern limits.

5. Pennsylvania has still another and more important iron region in the northwest, including the northeastern corner of Ohio. Here 66 furnaces have been in blast manufacturing iron from the buhrstone and other carbonaceous ores at the northern outcrop of the great Bituminous Coal Region. All the forging of this region is done in the Rolling Mills and workshops of Pittsburg and other centres of trade upon the Ohio waters.

6. The Ironton Region through which the Ohio river breaks above Portsmouth contains 45 furnaces on the Ohio and 17 on the Kentucky side, some of which use the coal of the mine for fuel, and all of them the ores of the coal measures for stock.

7. The old iron-making region of middle and eastern Virginia, a prolongation of the Pennsylvania region across the Potomac, supplied with the same brown hematite and magnetic ores, contains 16 furnaces in its division east of the Blue Ridge only one of which is in blast, and 30 furnaces west of the Blue Ridge. It has also 35 forges.

8. In the northern part of East Tennessee, and northwest corner of North Carolina, is seen a knot of 41 bloomary forges and 9 furnaces using the hematite and magnetic ores of the Highland range; while to the west of them at the base of the Cumberland Mountains, and on the outcrop of the fossiliferous "dyestone" ore of the upper silurian rocks, are 14 forges and 5 furnaces. In the southwestern corner of North Carolina are 5 forges of the same kind, and further to the east is a belt through the centre of North Carolina passing over the line a few miles into South Carolina consisting of 27 forges and 5 furnaces. There is also a small iron region in northern Georgia along the line of the Chattahooche, which passes over into Alabama. This whole country possesses an incalculable, inexhaustible abundance of the richest ores, while its production of iron still remains at a minimum.

9. There is as yet but one principal iron region in the far west, that of western Tennessee and western Kentucky, with its peculiar ores, and 45 furnaces, and six or eight forges; but

10. In Missouri a beginning has been made with the Iron Mountain as a centre, and there already exist 7 furnaces in blast upon brown hematite and primitive ores.

Tabulating these regions we obtain their relative importance as follows:

Production of Furnace Pig Iron of the different regions, in the order of Quantity Produced.

		1854		1855		1856	
Anthracite.	In Pennsylvania		208,703		255,326		306,972
"	Out of Pennsylvania		99,007		87,779		87,537
Charcoal and Coke	S. Ohio	56,081	79,010	47,982	64,162	70,455	92,116*
	E. Kentucky	22,929		16,180		21,661	
" "	W. Pennsylvania	78,927	90,216	59,388	69,314	59,597	76,653*
	N. Ohio	11,289		9,926		17,056	
" "	E. Pennsylvania		62,724		60,596		52,775
Charcoal	W. Tennessee	37,918	53,054	33,683	50,347	32,162	50,664
	W. Kentucky	12,236		13,664		14,902	
	S. Indiana	1,400		1,500		1,800	
	S. Illinois	1,500		1,500		1,800	
Charcoal and Coke	S. W. Pennsylvania	11,052	12,982	18,217	20,559	29,400	30,867
	N. W. Virginia	1,930		2,342		1,467	
" "	Maryland		35,658		36,309		30,998
Charcoal	E. of the Hudson		30,420		32,826		29,937
"	N. and W. New York		19,197		19,736		18,847
"	" Missouri		7,591		10,181		10,138
"	S. New York and N. New Jersey		13,435		7,901		5,683
"	E. and Mid. Virginia		5,880		6,926		5,730
"	N. and S. Carolina	1,820	6,056	1,830	6,061	1,956	7,694
"	Georgia	2,391		2,715		2,807	
"	E. Tenn. and Alabama	1,845		1,516		2,931	
"	" " Michigan	990	990	950	950	3,678	6,178
"	" " Wisconsin					2,500	
Total Production of Pig Metal in the United States			724,833		728,973		812,917

Increase of production from 1854 to 1855 .... 4,140 = .6 per cent

Increase of production from 1855 to 1856 .... 11 per cent = 83,880

Total increase of production from 1854 to 1856 .... 12 per cent = 88,020

The entire production of raw metal from the furnaces in 1856 was a little over *eight hundred thousand* tons. The tables show much less change in the manufacture from year to year over the whole Union than was supposed to have taken place, judging from common rumor and local disconnected information. But they also show large local fluctuations and even permanent reversions of the rate of increase, and very different proportions for different regions. It is hardly necessary to add that they are sadly far from showing anything like the increase which the imperfect statistics of 1857 encouraged us in anticipating. Throughout the charcoal smelting regions, especially of the West, the year 1855, a year of drought, was also a year of feeble production. But for this drawback the *total productions* of the following table would have shown a more regular rate of increase; yet that increase would not have amounted to more than 40 or 45,000 tons a year, or about *six per cent* on the whole production. The production of 1857 was not greatly influenced by the crisis of October, and yet is now seen not to have reached that of 1856, as will appear further on.

As to the local variations, the anthracite branch of the manufacture is seen to mount rapidly from year to year, being 115,000[3] tons in 1849, and 307,710 tons in 1854, an increase of nearly 200 per cent in 5 years, equal to a regular annual increase of *twenty-two per cent.* In 1855 it was 343,105 tons; a further increase of *twelve per cent.* In 1856, 394,509 tons; a further increase of nearly *thirteen per cent.* Whereas the increase of the whole iron production was but 6 per cent—a fact to be explained by the steady conversion of charcoal into anthracite furnaces, the enlargement of their capacity and especially the concentration of capital about the geological centre of fuel in Pennsylvania. This is evident from the fact that the anthracite production outside of Pennsylvania has *diminished* in the same time by an annual rate of over *six per cent* from 99,007 to 87,537 tons; which raises the Pennsylvania anthracite annual increase still higher, namely, to over *twenty-two per cent*, which curiously enough is exactly the annual increase of the whole anthracite production from 1849 to 1854, as stated above. Respecting the production of 1857 replies have lately been

[3] Estimating for furnaces No. 3, 6 and 13; it is 107,256 tons in the table p. 63.

received from 71 of the 121 anthracite furnaces, by which it appears that these 71 furnaces which made in 1856 286,160 tons, made in 1857 281,980, or 4,180 tons less. If the remaining 50 furnaces preserved this proportion, the productions of 1856 and 1857 would appear to have been nearly the same; but the furnaces not heard from are the ones most likely to exhibit a heavy decline of production. The crisis of 1857 has reduced the production of 1858 to perhaps one-half that of 1857. Although it occurred too late in the season of 1857 to exert a great effect upon the production of 1857, we can ascribe to no other agency this falling off of the production of 1857 behind that of 185 thus exhibited.

Anthracite Production of 1857, *as heard from;* 71 *Furnace*

	No. heard from.	1856.	1857.	
Outside of Pennsylvania	11 out of 27	42,676	44,612	
In the Lehigh Valley	20 out of 24	121,021	113,299	
In the Schuylkill Valley	15 out of 22	43,275	48,310	5
Along the main Susquehanna	15 out of 26	39,704	35,257	—
Along the N. & W. Branches	10 out of 22	39,484	40,502	1,0
Totals		286,160	281,980	—

There must have been a proportionate decrease als production of charcoal iron, and this decrease must h even greater than it appears at first glance, because th of coke iron has been at the expense of this charcoal ture, and not at the expense of the anthracite product charcoal regions in western Pennsylvania and Ohio invaded also by the raw bituminous coal process. T **coal and Coke Iron production** from 1854 to 185

In New England and New York, fell off		
S. N. York and N. Jersey,	"	
Eastern Pennsylvania,	"	
Maryland,	"	
South of the Potomac,	"	
N. W. Penna. and N. Ohio,	"	
W. Ky. W. Tenn. Ind. and Ill.	"	
Total falling off, [6]	"	

[4] Add 1,340 for increase of coke iron in this region.

[5] Deduct 2,300 for decrease of coke and raw coal iron in this re

[6] "It is noteworthy that the decrease of the charcoal iron pr portion to the accessibility of the regions to the seaboard and to stance, east of the Alleghanies shows a falling off. Northwestern P sible from the lakes and the Erie Canal; and western Kentucky an Orleans." (C. E. Smith.)

ı S. W. Penn. and N. W. Virga. increased,	17,185 [7]	tons
S. Ohio and E Kentucky, "	13,106 [8]	tons
Missouri, "	4,676	tons
Michigan and Wisconsin, "	4,950	tons
Total increase,	39,917	tons
Balance against increase,	6,356	tons

If from this account we take away the Coke and Raw Coal manufacture which was 54,485 tons in 1854, and 69,554 in 1856, the above exhibit against the prosperity of the charcoal iron manufacture will appear still worse.

Charcoal Iron.

New England and New York, fell off,	4,683	tons
...rk and New Jersey, "	7,752	tons
...nsylvania, "	13,179	tons
"	4,660	tons
... Potomac, "	,550	tons
... Ohio, "	11,763	tons
... etc., "	2,726	tons
...ng off,	45,313	tons

Charcoal Iron.

and N. W. Va. increased,	75	tons
...l E. Kentucky, "	16,885	tons
"	4,676	tons
... and Michigan, "	4,950	tons
...ease,	26,586	tons
...gainst Increase,	18,727	tons

... two regions the manufacture of charcoal iron is ...ty. Of the 73 furnaces of Clarion, Venango and ...nties Pennsylvania, one of the most productive ...e United States, 37 are abandoned, and the feeling ... Clarion county is that in five years hardly a char... will be in use.

... Tennessee into which Pennsylvania Iron-men ad...nty years ago to build up the manufacture of iron ...ge fortunes, and were thought to have established ... a steady increase was more than an anticipation ... tables show a steady decline, from 1854 to 1857, ...383, 31,026 to 27,050 tons. Had this decline ...55, we should ascribe it to the year of drought ...n all over the west. Had it been confined to ... cribe it to the effects of the insurrection of

...e establishment of the Cambria Iron Works at Johnstown, the ...3,399 tons in 1854, and 24,209 tons in 1856.

...ase of raw coal iron in this region.

48

Christmas 1856, which caused many of the furnaces to go out of blast; but the focus of that disturbance was in Kentucky, where the same table (K. page 159) shows as steady an increase of production through the same four years, from 12,236, 13,664, 14,902 to 15,808 tons. There seems no escape from the conviction that in spite of the old establishment of the manufacture and wealth of ore deposits south of the Kentucky-Tennessee line, the capital and energy of the trade is moving northward down the two great rivers of that region, towards the Ohio and its rolling mills. The establishment of the Paducah, Covingto[illegible] and Indianopolis mills and the opening up of the Missouri [illegible] region will facilitate this change. On the other han[illegible] pletion of the Lexington and Clarksville railroad, [illegible] Kentucky bituminous coal down into the heart of th[illegible] iron region will undoubtedly retard it and may by [illegible] prise be made to inaugurate a new era of prosperity [illegible] Tennessee. At present only 15 of its 42 furna[illegible] blast (August 1858).

In striking contrast to the last described region sta[illegible] southern Ohio and eastern Kentucky, called the Hang[illegible] 30 of its 59 furnaces having been erected since 185[illegible] its production fell off nearly 15,000 tons, and in 18[illegible] 28,000, making this region second only to the anthr[illegible] of Pennsylvania for the importance of its iron pro[illegible] in 1856 reached 92,116 tons, and in 1857 96,000[9] t[illegible]

The west Pennsylvania and northern Ohio regio[illegible] gan with 90,000 and fell off in 1855 21,000 tons, [illegible] 1856 to 76,000, thus reversing the exhibition of [illegible] Rock region and showing a tendency of the man[illegible] ward, down the Ohio, precisely analogous to t[illegible] pointed out in western Tennessee.

In eastern Pennsylvania the charcoal iron p[illegible] diminished regularly in three years from 6[illegible] 51,775, although these numbers include the pro[illegible] ral coke furnaces at the head of the Juniat[illegible] crease of charcoal iron alone was 13,179 tons.[1]

[9] A certain number of furnaces having reported in 1857, t[illegible] years for these furnaces gives 60,218 : 62,779 = an increase of [illegible] held good for the whole number of furnaces it would give 3,70[illegible]

[1] Mr. C. E. Smith showed the decrease from 1847 to 1849 in [illegible] to be 94,519 - 58,302 = 36,217, and in Penn. char. cold blast iro[illegible]

In New England, New York, New Jersey, Maryland and the States south of the Potomac the charcoal iron manufacture has fallen off and apparently from some general and chronic cause, and is moving its centres westward to the limits of the bituminous coal fields, and to the new iron lands of Missouri, Wisconsin and Michigan.

The production of last year (1857) promised in the spring and summer to be a large increase upon that of 1856, but the panic of September and the subsequent withdrawal of credit from the manufacturing energy of the country stopped most of the rolling mills and obliged some of the furnaces to go out of blast. Many continued to run up their stock but ceased to procure fresh supplies of ore, and the winter has passed at many furnaces with almost no attempt at coaling. The anthracite region of the Lehigh is prominent in continuing to make iron; its production will probably reach two-thirds of its ordinary amount. But in the Schuylkill, and Lebanon valleys 22 out of 28 anthracite furnaces were idle in May last, and in the Susquehanna and Juniata valleys 15 out of 20. We may state that at present not more than 50 or 60 out of the whole 121 anthracite furnaces of the northern States are making iron.

In northwestern Pennsylvania in January last only 20 charcoal furnaces continued in blast, some of which were running out stock.

In the great Ironton region of southern Ohio and eastern Kentucky in January last there were a large number standing still, and many of those in blast were making small preparation for the coming year. This year is already far enough advanced to make it certain that its general production of iron in the United States will fall off to perhaps one-half of that of 1857; the tone of the replies to the circular of July 1, was almost without exception angry and desponding (Aug. 1858).

The **second** department of the Iron Manufacture represented by Forges, is divisible into two parts. Bloomary Forges are small blast furnaces with open fronts like blacksmith fires intended to reduce the finer kinds of ore directly into a mass of iron which is placed under a tilt hammer and drawn out into a slab or anchony.

34,490. His statistics for 1850 continued the decline, giving for P. C. hot B. 42,555, P. C. cold B. 70,727. (Appendix to Report of Committee on Statistics, page 103.)

The bloomaries of the United States produce 28,633 tons of malleable iron directly from the ore.

Other forges are adjuncts to the blast furnaces and deal with their pigs of cast iron in like manner, converting them into blooms or slabs of malleable iron ready for reheating in the rolling mill. North of the Potomac 38,158 tons of malleable iron are thus forged, and 3,475 south and 11,611 west of it; in all 53,244 tons.

A few forges deal with scrap iron chiefly, but they differ in no respect from other forges.

It is a great geographical feature in the iron manufacture of the United States that nearly all the forges are on the Atlantic side of the Alleghany Mountain. The Bloomaries are so located because they stand upon the magnetic ores; but the common charcoal or German forge of the eastern valleys is replaced upon the waters of the Ohio by the puddling furnace of the rolling mill.

There is a third division of the forges that use their hammers, which are often of great size and weight, in true forging, in making shafts, cranks, axles, anchors, chains, anvils, and all kinds of heavy iron-work. This sort of forge is of every size and graduates downwards into the hand forge of the machine shop or smithery. Our tables however are confined to separate forges, of all three kinds. Of this heavy machine-forging 7,137 tons are done north of the Potomac, and about 5,000 tons in the west.

The **third** department of the Iron Manufacture is occupied by the Rolling Mills, which, take the cast iron of the furnaces and the charcoal iron of the bloomaries and common forges, refine it in puddling furnaces, roll it into rough bars, cut, pile and reheat these in heating furnaces and roll them into rails, merchant bars, and plates and sheet-iron of all kinds for all the purposes of manufacture. Attached to all the old and many of the new rolling mills we find the nail, spike, railroad chair and horseshoe factories. The rolling mills are to be distinguished therefore into rail mills, boiler-plate mills, nail mills, and merchant bar mills, the first three having a certain geographical distribution, and the last being found in all parts of the iron making regions.

1. The rail mills of the United States are

			Tons of rails.
The Bay State, South Boston, which made in 1856		....	17,871
The Rensselaer, Troy, N. Y.,	"	....	13,512
The Trenton, N. J.,	"	about............	13,000
The Phœnixville, Pa.,	"	....	18,592
The Pottsville, Schuylkill Co., Pa.,	"	....	3,021
The Lackawanna, Luzerne Co., Pa.,	"	....	11,338
The Rough and Ready, Danville, Pa.,	"	....	5,259
The Montour, "	"	....	17,538
The Safe Harbor, Lancaster Co., Pa.,	"	....	7,347
The Mount Savage, Cumberland, Md.,	"	....	7,159
The Cambria, Cambria Co., Pa.,	"	....	13,206
The Brady's Bend, Armstrong Co., Pa.,	"	....	7,533
The Cosalo, Lawrence Co., Pa.,	"	....	000
The Washington, at Wheeling, Va.,	"	....	2,355
The McNickle, at Covington, Ky.,	"	....	1,976
The Newbury, near Cleveland, Ohio,	"	....	000
The Railroad Mill, at Cleveland,	"	....	000
The Wyandotte, near Detroit, Mich.,	"	....	1,848
The Chicago, in Illinois,	"	....	000
The Indianapolis, in Indiana,	"	....	000
Total above make of Rails in 1856		....	141,555

The last four mills have been recently started with the intention of re-rolling western rails. The Fairmount at Philadelphia, has been also recently adapted to rolling rails; and the Palo Alto at Pottsville, rolled a thousand tons or so, in 1856. There were therefore made 142,555 tons of railroad iron in 1856, of which two-thirds were made in Pennsylvania.

The extension of this branch of the iron manufacture will be seen by the following comparison of four years:

	Made.	Imported.	Total of consumption.
[2]1853	105,000 tons	298,995	403,995
[2]1854	121,000	282,867	403,867
[2]1855	134,000	127,516	261,516
1856	142,555	155,496	298,051

2. The principal boiler plate and sheet iron mills of the United States are centered geographically about Philadelphia:

	Tons.
East of the Delaware there are but two mills, both at Jersey City, which made in 1856	550
In E. Pennsylvania on the Schuylkill and lower Susquehanna there are 25 mills which made in 1856	21,218

[2] There is some reason to fear that several rail mills overstated their production from 5,000 (in the aggregate) to 10,000 tons, and that it would not be unsafe to give for 1853, '4 and '5, the following figures—100,000, 110,000, 125,000. The figures for 1856 must furnish a very close approximation to the truth.

Brought forward	21,768
Near Wilmington, Delaware, 3 mills made	1,374
Between Wilmington and Baltimore 7 miles made	2,998
In Pittsburgh 14 mills made, besides bars, rods, hoops and nails, boiler iron 3,212, and sheet iron to the extent of 6,437	9,649
Sheet iron at the Sharon Mill, Mercer Co.	? 500
The Bloom Mill at Portsmouth, S. Ohio, and the Globe Mill at Cincinnati, made about	2,000
A mill for boiler plate has been erected at St. Louis.	
Total	38,639

3. The nail mills on the other hand have but two principal centres; one in southeastern New England, and one at Pittsburg. Many small nail mills have stopped, as the profit has been reduced to the lowest point by competition. It is not so easy to obtain the amount of nails made, because many mills still include nails among their productions for their home market. The following table will approximate to the truth in the matter of production:

	Tons.
In southeast New England 12 mills made (1856) of nails principally	25,000
Troy, New York	4,000
Rockaway, Boonton, (2) N. Jersey, nails, spikes	8,250
In southern New Jersey	4,167
On the Schuylkill were made in 5 mills about	9,000
On the lower Susquehanna in 2 mills about	2,600
In middle Pennsylvania in 2 mills about	2,000
In Maryland at 2 mills	2,155
In Richmond 1 mill	1,075
In Pittsburg 14 mills made nails, spikes, rivets, tacks	14,195
In Wheeling, 2 mills made	6,465
In Ironton, southern Ohio, 1 mill made	775
In Mahoning Co. N. E. Ohio, 1 mill made	380
In Buffalo	1,400
Total, nails	81,462

4. It is not easy to state the amount of tons of manufactured iron other than rails, plates and nails made in the rolling mills, as the rolling mills returns are less complete than any other kind, and more complicated. But Mr. Chas. E. Smith has successfully undertaken to do this in statements to occupy the following pages, by an analysis of the already published records, showing that, the total product of the rolling mills of the United States being 498,081 tons, the amount of manufactured iron other than rails, plates and nails, falling under this fourth head, is 240,000 tons.

J. P. Lesley, *Secretary.*

Statements showing the American production, the importation, and the total consumption of each kind of iron, in the United States for the year 1856,

COMPILED FROM THE FOREGOING TABLES, BY CHARLES E. SMITH.

I.

Product of Anthracite Pig Iron in 1856.

			Tons.	Tons.
Massachusetts	3	furnaces,[2]	4,443	
Connecticut	1	"	0,000	
New York,	14	"	47,257	
New Jersey	4	"	26,117	
Pennsylvania	93	"	306,972	
Maryland	6	"	10,720	
Total anthracite	— 121		———	394,509

1856. Av. value $25 in Phila., $9,862,725
1858. " " 20 " 7,890,180

Product of Coke Pig Iron in 1856.

Pennsylvania	21	furnaces,	39,953	
Maryland	3	"	4,528	
Total coke	— 24		———	44,481

1856. Av. value $25........ $1,112,025
1858. " " 21........ 934,101

Product of Raw Bituminous Coal Pig Iron in 1856.

Pennsylvania	6	furnaces,	8,417	
Ohio	13	"	16,656	
Total raw coal	— 19		———	25,078

1856. Av. value $25........ $626,825
1858. " " 21........ 526,533

Product of Charcoal Pig Iron in 1856.

Maine	1	furnace,	2,100
New Hampshire	1	"	000
Vermont	5	"	2,420
Massachusetts	7	"	8,564
Connecticut	14	"	12,876
New York	29	"	21,774
New Jersey	6	"	2,100
Pennsylvania	143[3]	"	96,154
Maryland	21	"	26,470
Virginia	39	"	14,828
North Carolina	3	"	450
South Carolina	4	"	1,506
Georgia	7	"	2,807
Alabama	3	"	1,495
Tennessee	41	"	28,476

[2] The works here set down are only those running, or in running order.

The discrepancy between this and Mr. Lesley's figures in the table on page 747 is due to the fact that there is an interval of two years between the dates of the two tables, the one representing the furnaces in working order in 1856, the other in 1858.

			Tons.	Tons.
Amount brought up,				464,063
Kentucky	30	furnaces,	36,563	
Ohio	41	"	70,355	
Indiana	2	"	1,800	
Illinois	2	"	1,900	
Missouri	7	"	10,138	
Wisconsin	3	"	2,500	
Michigan	7	"	3,678	
Total charcoal	——	416	——	348,854
1856. Av. value, $30 .... $10,465,620				
1858. " " 24 8,392,496				
Total product of pig iron in 1856				812,917

Total number of furnaces running, or in running order, 580.

Product in Blooms and Bars made direct from the ore by the Bloomary or Catalan process, in 1856.

Vermont,	5	bloomaries,	1,650	
New York,	42	"	18,710	
New Jersey,	48	"	4,487	
North Carolina,	36	"	1,182	
South Carolina,	2	"	640	
Georgia,	4	"	40	
Alabama,	14	"	252	
Tennessee,	50	"	1,222	
Michigan,	3	"	450	
Total product of	——	204	——	28,633

Of this quantity 7,000 tons were bars,
21,633 " " blooms.
1856. Average value $50 00, $1,081,650
1858. In Troy, N. Y.[4] 37 50, 811,237

Grand total production of iron from the ore, 1856, ... 841,550

II.

Statement of the total quantity of iron of all kinds consumed *in domestic forges, rolling mills and foundries, viz.:—*

Domestic product from the ore above stated,	841,550 tons.	
Deduct quantity sold in bars immediately to consumers by bloomaries, and therefore not entering into the manufactures embraced by this table,	7,000	
		834,550
Scraps imported,		10,320
" domestic (estimated),		25,000
Old rails,		100,000
Scotch pig imported,		55,403
Total,		1,025,273

[4] The largest market for this kind of iron.

Of this total, excepting Scotch pig therefrom, the following are the *proportions of pig, scrap, and old rails respectively consumed by domestic forges, rolling mills and foundries.*

Amount last stated,		1,025,273	
Deduct Scotch pig,		55,403	
			969,870
By forges, product,	53,244		
Waste,	17,748		
		70,992	
By rolling mills, product,	498,081		
Waste,	124,520		
	622,601		
Deduct blooms,[5]	60,877		
		561,724	
By foundries, domestic pig,		337,154	
			969,870

The Scotch pig imported was all consumed by the foundries; making, with the domestic pig, a total for this class of works, of 392,557 tons of pig.

It is impossible to make such an analysis of the foregoing statement, as shall show, separately, the exact amount of pig, and of scrap, respectively taken by the forges and the mills; but an approximate estimate may be made. Assuming that the country, or refinery forges take no scrap; and that the others use only scrap (which is very neary the fact), we shall obtain the following as *the consumption of domestic pig iron:*—

Domestic pig consumed by the forges,	52,325	
" " rolling mills,	423,438	
" " foundries,	337,154	
Making the total stated on the previous page,		812,917

III.

The product in 1856, of the forges, not bloomaries, *consuming pig and scrap*, was as follows:—

New Hampshire,	1 forge,	600 tons.
Massachusetts,	5 forges,	1,850
Connecticut,	6 "	1,950
New York,	3 "	1,360

[5] The total blooms produced from ore is ... 28,633
Sold direct in bars, ... 7,000

The total blooms produced from ore is		28,633
Sold direct in bars,		7,000
		21,633
Total blooms by refinery forges,	53,244	
Made into bars and shapes,	14,000	
The waste in making which is added under the head of forges in the text,	39,244	39,244
Total blooms going into mills,		60,877

Brought forward,			5,760 tons.	
New Jersey,	2	forges,	671	
Pennsylvania,	111	"	31,727	
Maryland,	2	"	480	
Virginia,	43	"	2,995	
Kentucky,	4	"	4,511	
Tennessee,	9	"	6,195	
Missouri,	3	"	905	
Total product of	189			53,244

Of this quantity there were made into bars, car and carriage axles, locomotive tire, shafts, anchors, and various shapes about	14,000 tons.	
And into blooms,	39,244 "	
1856. Average value Bars, etc., $120,	$1,680,000	
" " Blooms, 80,	3,139,520	
		$4,819,520
1858. Average value Bars, etc., $100,	$1,400,000	
" " Blooms, 70,	2,747,080	
		$4,147,080

IV.

The product of the rolling mills in 1856 was as follows:

Maine,	1	mill,	4,500 tons.	
Massachusetts,	19	mills,	55,292	
Rhode Island,	2	"	4,475	
Connecticut,	5	"	5,759	
Vermont,	1	"	500	
New York,	13	"	55,172	
New Jersey,	10	"	28,403	
Pennsylvania,	91	"	241,484	
Delaware,	4	"	2,211	
Maryland,	13	"	14,812	
Virginia,	12	"	26,355	
North Carolina,	1	"	215	
South Carolina,	3	"	1,210	
Georgia,	1	"	900	
Tennessee,	3	"	2,680	
Ohio,	15	"	30,980	
Kentucky,	7	"	16,865	
Indiana,[6]	1	"	000	
Illinois,[6]	1	"	000	
Missouri,	4	"	4,420	
Michigan,	2	"	1,848	
Total product of	209			498,081

V.

Looking at our subject from the point of view of *consumption*, we find that the following statement will represent the

[6] Not completed at this date.

quantity of iron of all kinds used in every form of domestic manufacture for general consumption, viz :—

Total of domestic iron produced from ore as before stated on page 760, 841,550 tons.			
Pig[7] iron	imported	55,403	
Rolled[7] and Hammered	do	298,275	
Scraps[7]	do	10,320	
Total	imported		363,998
To which add by estimate, old rails re-worked—	domestic,	100,000	
Scrap collected and sold	do	25,000	
			125,000
Grand total, ...			1,330,548 tons.

VI.

Examining the history of this total to ascertain the quantity and kinds of *rolled and hammered iron, obtained from all sources, consumed in the United States during* 1856, we find the following details:

	Domestic product. Tons.	Imported. Tons.	Total consumed. Tons.
Rails, ...	142,555	167,400	309,955
Boiler and sheet, ...	38,639	15,053	53,692
Nails (2,645 machines), ...	81,462		81,462
Bar, rod, band, and hoop, ...	235,425	115,822	372,247
Hammered bars and shapes, ...	21,000		
Amount of finished wrought iron which entered into general consumption in 1856, ...	519,081	298,275	817,356

VII.

To ascertain the *percentage respectively, of foreign and domestic iron of all kinds*, which entered into general consumption in the year 1856, we have

	Domestic.	Foreign.	Total.
Rolled and Hammered, as above, ...	519,081	298,275	817,356
Pig iron, ...	337,154	55,403	392,557
	856,235	353,678	1,209,913

Which results give the proportion of 70 per cent *domestic*, to 30 per cent *foreign*.

The 21,000 tons mentioned above as *domestic hammered bars and shapes*, were produced as follows:—

By bloomaries, bars, ...	7,000 tons.	
By forges proper, ...	14,000 "	
Total, ...		21,000 tons.

[7] To obtain the closest practicable approximation of *imports* for the *calendar* year 1856, the official returns, for the *fiscal* years ending the 30th of June, 1856 and 1857, have been averaged together. The result is in the text.

VIII.

The quantity of *foreign* imported hammered iron cannot be exactly ascertained because of a change in the Treasury classification, which took place in 1854, by which rolled and hammered bars are included in one class as "bar iron." For the 6 years previous to 1854, the amount of hammered bars averaged about 20,000 tons, which is probably nearly correct at this time.

Domestic,	21,000	
Foreign,	20,000	
Total consumption of hammered iron,		41,000

IX.

Of the total domestic production of pig, and rolled and hammered iron above stated, viz., 856,235 tons, the following are the quantity and value, shown with reference to the various kinds of product:—

		1856.		1858.	
		Price.	Amount.	Price.	Amount.
337,154	tons foundry pig,	$28[8]	$9,440,312	$22 00	$7,417,388
142,555	" rails,	63	8,980,965	48 00	6,842,640
38,639	" boiler and sheet,	120	4,636,680	100 00	3,863,900
81,462	" nails,	84	6,842,808	67 50	5,498,685
235,425	" bar, rod, band, hoop,	65	15,302,625	57 50	13,536,937
21,000	" hammered iron,	125	2,625,000	100 00	2,100,000
856,235	"		$47,828,390		$39,259,550

The total domestic pig iron made was	812,917	
Amount imported,	55,403	
Total pig iron consumed for all purposes		868,320

Total number of Iron Works.

Anthracite blast furnaces,	121	
Coke " "	24	
Raw bituminous coal " "	19	
Charcoal " "	416	
Total number of blast furnaces,		580
Bloomaries,		204
Forges,		189
Rolling mills,		209
Total of all kinds, running or in running order,		1,182

Number of double puddling furnaces in the mills,	208
" single " "	1,054

[8] Estimating 302,154 tons at $27, and 35,000 tons of cold blast charcoal iron for car wheels, malleable castings, and extra machinery, at $35. Average $28.

Total number in the rolling mills, counting the double furnaces as equal to two,	1,470	
Number in the forges,	34	
Total number in the United States,		1,504
Total number of bloomary fires,		442
" " refinery or forge fires proper,		496
" " nail machines,		2,645

In conclusion, it is proper to remark that the materials from which the foregoing summary has been prepared were obtained chiefly through the indefatigable industry of Mr. J. P. Lesley, Secretary of the Association, assisted by Mr. Jos. Lesley, Jr., and Mr. B. S. Lyman, during a period of nearly two years, at an expense of about six thousand dollars, defrayed entirely by the voluntary contributions of the members of the Iron Association.

The want of full and reliable information on the subject has been long felt, and several previous attempts had been made to procure it; but when the parties to these, after more or less progress in the accomplishment of their design, came fully to appreciate the vast field which it was necessary to canvass, and the great labor and expense incident to their purpose, they abandoned it in despair.

This comprises, therefore, the first and only complete statement of the iron industry of the Union. No expense or pains have been spared to make it perfectly accurate. In so extended an inquiry some errors of detail are to be expected, and such, no doubt, will be found, although not at present known to exist. No error, however, can be discovered which will affect the general result. The tables are as accurate as it is possible, from the nature of the case, to make them.

The great facts demonstrated are, that we have nearly 1,200 efficient works in the Union; that these produce annually about 850,000 tons of iron; the value of which in an ordinary year is fifty millions of dollars. Of this amount the portion expended for labor alone is about $35,000,000.[9]

[9] The proportion of labor in the price of a ton of pig iron is about 60 per cent. In rails and bar iron about 66 per cent. In the smaller and finer descriptions of iron about 75 per cent.

The amount of **rolled iron** made in the whole United States is about 500,000 tons per annum. Of this about 300,000 tons is made east, and 200,000 tons west of the Alleghany mountains.

The annual average importation of rolled iron for the eight years from 1850 to 1857 inclusive, was about 305,000 tons, of which the Atlantic States consumed about 200,000 tons, making the total consumption of *rolled* iron in the seaboard States about 500,000 tons per annum, three-fifths of which is domestic and two-fifths foreign.

The 105,000 tons of foreign iron consumed in the west and southwest is nearly all composed of rails. The smaller descriptions of iron consumed there are chiefly of domestic manufacture. At least seven-eighths of all the descriptions of imported iron, except rails, are consumed in the Atlantic States.

The annual importation of railroad iron for the eight years, 1850 to 1857, averaged 202,000 tons, of which about one-half has been taken by the Atlantic States.

CHARLES E. SMITH.

CHAPTER V.

THE DEMOCRATIC PRINCIPLES INVOLVED IN AND ILLUSTRATED BY THE IRON MANUFACTURE.

The political questions which arise and centre in the question of a Tariff embrace interests too extensive to be circumscribed within the iron regions of this or any other land. All the manufactures of an infant colony must be fostered, like all the energies of an infant family, until with time and manhood, the nation, like the individual, full formed, mature and independent, may convert its previous necessities into arguments for cosmopolitan good-will, and find itself prepared to abate its claims to the right of undisturbed self-government, for the higher purpose of extending the exercise of the same right to the feebler races and nationalities of the common planet. The theory should follow—not precede the practice. Tariffs must prepare the world for Free Trade. Home industry is more needful and nobler than the luxuries of foreign commerce. The solution which has no centres of crystallization precipitates an amorphous, incoherent, friable mass; and the government which systematically prejudices the conditions of manufacturing life against both the capital which seeks locations and the skilled labor which asks employment, is anti-democratic, and in America is certain to be overturned.

But this subject is worthy of larger space and more careful elaboration than can be afforded to it here.

MANAGERS FOR 1859–60.

G. N. ECKERT, . . .	Philadelphia, *President.*
J. H. TOWNE, . . .	Philadelphia, *Vice-Pres.*
C. E. SMITH, ...	Philadelphia, *Treasurer.*
Hon. D. R. PORTER, . .	Harrisburg,
S. J. REEVES, . . .	Philadelphia,
STEPHEN COLWELL, . .	Philadelphia,
W. M. LYON, . . .	Pittsburg,
ELIAS BAKER, . . .	Altoona, (Penn.)
JNO. McMANUS, . . .	Reading, (Penn.)
JNO. H. REED, . . .	Boston,
C. C. ALGER, . . .	Hudson, (New York.)
JAS. MYERS, . . .	Columbia, (Penn.)
G. D. COLEMAN, . . .	Lebanon, (Penn.)
J. W. TYSON, . . .	Baltimore,
AB. S. HEWITT, . . .	New York,
JNO. A. WRIGHT, . .	Lewistown, (Penn.)
PERCIVAL ROBERTS, . .	Philadelphia,
CHAS. S. WOOD, . . .	Johnstown, (Penn.)
H. N. BURROUGHS, . .	Philadelphia,
JOHN CAMPBELL, . .	Ironton (Ohio),
GEO. T. LEWIS, . . .	Clarkesville (Tenn.)

AMERICAN IRON ASSOCIATION.

CONSTITUTION.

WHEREAS, the manufacture of iron, in its various branches, has acquired an importance in this country second only to the great agricultural interest; and whereas, its more rapid and economical development has been retarded by want of unity of action and free intercommunication of opinions and experiences among those interested; and whereas, we believe great advantages are best obtained by united action, we therefore deem it important to form an association in this city, to be called the AMERICAN IRON ASSOCIATION.

The general objects of this Association shall be to procure regularly the statistics of the trade, both at home and abroad. To provide for the mutual interchange of information and experience, both scientific and practical. To collect and preserve all works relating to iron, and to form a complete cabinet of ores, limestones, and coals. To encourage the formation of such schools as are designed to give the young iron-master a proper and thorough scientific training, preparatory to engaging in practical operations. And, generally, to take all proper measures for advancing the interests of the trade in all its branches.

ARTICLE I.

The affairs of the Association shall be conducted by a board of twenty-one managers, to be chosen annually by ballot, on the second Wednesday of March, by the members of the Association. They shall continue in office one year, and until others be chosen, and shall have power to fill vacancies that may occur in their body. They shall, from among their members, at their first stated meeting, elect a President, a first and second Vice-President, and a Treasurer.

Three members shall constitute a quorum at any meeting of the Board of Managers. The first election shall be held on the sixth day of March, A.D. 1855.

ARTICLE II.

The Association shall meet on the second Wednesday of March, June, September and December in every year. The President, or, in his absence, either of the Vice-Presidents, shall call a meeting of the Association whenever requested by ten members, in writing: Provided, that the first stated meeting shall be held on the sixth day of March, A.D. 1855.

ARTICLE III.

The Board of Managers shall meet statedly on the second Monday in every month, for the transaction of such business as may come before them, and, at the stated meeting in March, shall lay before the Association a report of the proceedings of the year. The meetings of the Board of Managers shall always be open to every member of the Association to take part in the proceedings, but to have no vote upon any question.

ARTICLE IV.

The funds of the Association shall be at all times subject to the control and disposition of the Board of Managers, but they shall have no power or authority to enter into any contract whatever in behalf of the Association, nor are the members to be at any time accountable for any contracts made by the Directors, beyond the funds in the hands of the Treasurer.

ARTICLE V.

All persons, firms, or incorporated companies, interested in the manufacture of iron in the United States, may become members of the Association upon paying a contribution fee annually, in advance, as follows:

For one charcoal furnace, . . .	ten dollars.
More than one " . . .	twenty dollars.
One mineral coal " . . .	twenty "
More than one " . . .	forty "
One rolling-mill, ...	twenty "
More than one rolling-mill, . . .	forty "
All other description of works, . .	five dollars each.

Provided, that no one individual, firm, or company, shall be required to pay an annual contribution of more than forty dollars. Persons not engaged in the manufacture of iron, but whose pursuits are in harmony with the objects of this Association, may be elected members by the Board of Managers, and shall pay an annual contribution of twenty dollars. Honorary or corresponding members may also be elected by the Board of Managers.

All members chosen by the Board shall be elected by ballot, and the affirmative vote of two-thirds of the members present shall be necessary to elect. The candidates for election shall be nominated at one stated meeting, and the election take place at the next or some subsequent stated meeting. All members elected by the Board shall be reported to the next meeting of the Association.

Any member who refuses the payment of his contribution for one year, shall not be entitled to vote. Should payment of the same be omitted for two years, his right of membership in the Association shall be forfeited, but he shall not thereby be released from the payment of his arrears. The resignation of any member not in arrears, shall be accepted by the Board of Managers.

ARTICLE VI.

Firms and incorporated companies shall be entitled to only one vote. Incorporated companies must be represented by one of their officers, or by a member of their Board of Managers, duly appointed for the purpose.

ARTICLE VII.

The Board of Managers shall have power to make such By-Laws as may be deemed necessary, not inconsistent with this Constitution; to employ a secretary; and to allow him such compensation as they may think proper.

ARTICLE VIII.

Any alteration or amendment in these articles shall be proposed at a stated or special meeting of the Association, to be approved by two-thirds of the members present.

BY-LAWS.

ARTICLE I.

President.—The President shall preside at the meetings of the Board; he shall sign all orders upon the Treasurer when the accounts shall have been passed by the Board; and shall call special meetings whenever he shall receive a written request signed by three members. In his absence, one of the Vice-Presidents shall preside, and should neither be present, a chairman *pro tem.* may be chosen.

ARTICLE II.

Treasurer.—It shall be the duty of the Treasurer to receive all the moneys of the Association, and to deposit them in the name of the Association, in such institution as the Board may direct. He shall make no payments without written vouchers from the Board. He shall keep accurate accounts of the income and disbursements, and shall exhibit accurate statements of his receipts and payments at the stated meetings, and whenever called upon by the Board. He shall, if required, give bonds for the faithful performance of his trust.

ARTICLE III.

Secretary.—The Secretary shall keep correct records of all proceedings of the Board, subject at all times to the inspection of any of its members. He shall keep a roll of the members' names, and at every meeting note the absentees and also those who attend later than the fixed hour of meeting. He shall notify every committee of its appointment through the chairman within two days, and shall issue notices of every special meeting of the Board. He shall attest all orders drawn by the Board. He shall have charge of the room of the Association and of all their property, except that in charge of the other officers or committees. He shall not lend any document or paper of the Board to any member thereof without a receipt. He shall act as corresponding secretary and answer all letters addressed to the Association; and open and maintain such correspondence as may tend to advance its interests, and keep a record thereof, subject to the direction of the Board. He shall acknowledge all donations, and shall notify honorary and corresponding members of their election. He shall act as secretary for all standing committees. He shall, under direction of the Committee on Statistics, collect statistics, specimens for the cabinet, and publications; and generally devote his time to the promotion of the objects of the Association. All bills must be examined and signed by him before presentation to the Board, and he shall report at each stated meeting of the Board, except when absent on duty.

ARTICLE IV.

Meetings.—The stated meetings of the Board shall be held on the evening of the second Monday in each month, at eight o'clock. A fine of ten cents shall be levied on each member who is absent when the hour of meeting arrives, and an additional fifteen cents shall be due from each member who does not appear during the meeting, except in case of sickness or absence from the city.

ARTICLE V.

Order of Business.—The order of business at the meetings of the Board shall be as follows:

1. Calling the roll.
2. Reading minutes of last meeting.
3. Reports from Secretary and Treasurer.
4. Reports from Standing Committees.
5. Reports from Select Committees.
6. Unfinished business.
7. New business.
8. Calling the roll.

ARTICLE VI.

Standing Committees.—Standing committees on the following subjects shall be nominated by the President or Chairman, and be approved by the Board, viz:

1. On statistics.
2. On finance.

They shall keep regular minutes of their proceedings, and report them monthly to the Board. Select committees may be appointed in any usual manner.

No committee shall have power to contract any debt unless previously authorized by the Board of Managers, and an appropriation made by them.

No bill shall be paid without having been first passed at a regular meeting of the committee incurring the expense, and being certified as correct by the chairman of that committee.